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한국 팹리스 시스템 반도체 발전을 위한 스마트계약 기반 거래 모델

Smart contract-based Business Model for growth of Korea Fabless System Semiconductor

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[요 약]

4차 산업혁명 기반에서 인공지능(AI), 전기자동차 및 로봇 등의 급속한 기술발전에 있어 반도체가 핵심성능을 좌우하면서, 반도체 경쟁력이 국가 경쟁력과 직결되는 상황을 맞이하였다. 하지만, 한국 반도체 산업은 메모리 반도체를 제외한 시스템 반도체 분야에서 지속적으로 경쟁력이 약화되어, 본 연구에서 침체기에 빠진 한국 팹리스 시스템 반도체 기업의 성장에서 가장 시급한 세계시장 개척을 위해 새로운 스마트계약 기반 블록체인 거래모델인 F-SBM (Fabless-Smart contract based Blockchain Model)을 제안한다. 본 연구는 새로운 F-SBM 모델을 통해 반도체의 Technology, Economy, Reliability 항목의 스마트 계약 기반 컨소시엄 블록체인을 통해 팹리스 업체의 신규고객 확보방안을 검증하였다. 이는 한국 팹리스 시스템 반도체 산업의 숙원인 세계 시장 개척을 위한 신규고객 확보의 높은 진입장벽이 개선됨과 새로운 성장방안을 도출하였다는 측면에서 큰 의의를 가진다.

[Abstract]

In the rapid technological development of artificial intelligence (AI), electric vehicles, and robots based the fourth industrial revolution, semiconductors determine the core performance, and semiconductor competitiveness is directly related to national competitiveness. However, the Korean semiconductor industry has continuously weakened its competitiveness in the system semiconductor field, excluding memory semiconductors, so in this study, a new smart contract basedblockchain business model to engage the global market, which is the most urgent need for the growth of Korean fabless system semiconductor industry in recession. F-SBM (Fabless-Smart contract based Blockchain Model) proposed. In this study, through the new F-SBM, it was verified how to engage new customers for fabless firms through smart contract based consortium blockchain regarding technology, economy, and reliability items of fabless. This model has great significance in improving the high entry barriers to engaging new customers for the long-cherished desire of the Korean fabless system semiconductor industry and deriving new growth solutions.

Key word : Semiconductor industry, System semiconductor, Fabless firm, Blockchain, Smart contract.

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Ⅰ. Introduction

Semiconductors began with transistors at Bell Labs in the U.S. in 1947, integrated circuits by Texas Instruments (T.I., Texas Instruments) in 1958, DRAM and CPU development by Intel in the 1970s, and generalization of PCs and smartphones. Today, the size of the semiconductor industry is about $600 billion in 2021 and has achieved rapid growth of 24.2% compared to the previous year. Semiconductors have been the No. 1 product of Korean export items for nine consecutive years, driving economic growth. Korearanked 2nd in global semiconductor market share for nine consecutive years (U.S. 50%, Korea20%, Japan 9%, Taiwan 8% in 2021) and world 1st in memory semiconductor for 30 consecutive years (59% share in memory market in 2021, DRAM 71%, NAND 47%), despite the external performance, the semiconductor ecosystem is very weak compared to competing countries in terms of fabless, research personnel, and technology [1].

Fig. 1. Worldwide IC firm Market share (IC Insights 2021)
그림 1. 전세계 반도체 시장 점유율 (IC Insight 2021)

Fig. 1 shows semiconductor firms worldwide classify into IDM (Integrated Device Manufacture; Intel, Samsung, Micron) firms that manufacture and design simultaneously and fabless (Qualcomm, Nvidia, MediaTek) firms that specialize only in design. Koreaand the US account for more than 80% of IDM semiconductor firms, but the US has competitiveness in major semiconductor fields such as system semiconductors (Intel), memory semiconductors (Micron), and analog semiconductors (Texas Instruments). However, Koreais dependent on memory semiconductors. It is a deformed structure in which the two IDM firms, Samsung Electronics and SK Hynix, occupy the entire market share. In addition, Koreafabless semiconductor industry, which only designs system semiconductors without a foundry, has a 1% share in the global market, showing competitiveness far behind Taiwan's 21% share and China's 9% share [2].

The fabless semiconductor business needs to grow by securing customers early. In particular, even if new fabless firms have competitive technology, they lack of mass production experience and less well-known, that's why set firms prefer to avoid applying it. Under those kind of industrial environment, even if new fabless firms make competitive semiconductors, actual set firms are reluctant to mass-produce them, making it more difficult for new firms to enter and expand their business in global market [3].

Ⅱ. Theoretical background

2-1 Korean fabless system semiconductor industry

A fabless firm specializes in semiconductor design and is a compound word for "fabrication" and "less," fabrication means semiconductor manufacturing facilities. It appeared in the United States in the 1980s, and representative firms include Qualcomm and Broadcom [4].

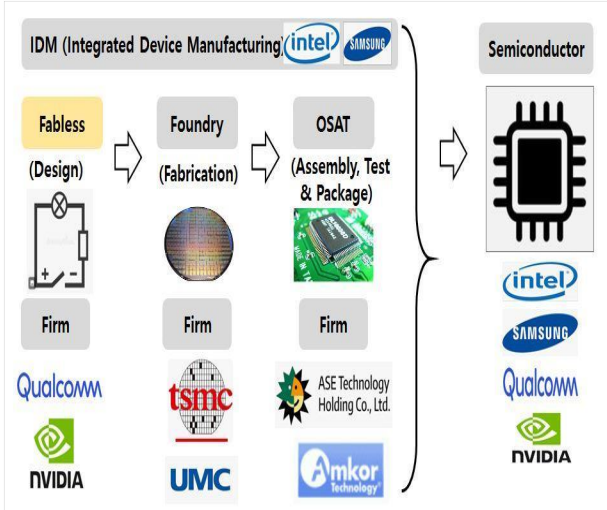


Fig. 2. Fabless Business of Semiconductor Industry (Kang,2022)
그림 2. 반도체 산업의 팹리스 사업 (Kang, 2022)

Fig. 2 shows IDM semiconductor firms carry from design into specialized steps in manufacturing and packaging internally. Fabless is specializing only in design closely collaborate with foundry firms that manufacture chips and OSAT (OutSourcing Assembly Test) firms that package and test. It is essential to secure on-time production and

competitiveness by establishing. A fabless firm is specializing only semiconductor design area and they are outsourcing from fabrication and OSAT(OutSourcing Assembly Test) steps by externally firm . OSAT firm is specializing in packaging and testing steps .Recently, to implement semiconductor functions that are becoming more diverse and complicated, there is a trend segmented step by step into Fabless, Foundry, and OSAT firms rather than traditional IDM firms [5].

Table 1. Worldwide Fabless Semiconductor firm Revenue Ranking (Trendforce, 2022/ Unit:US$1M)
표 1. 전세계 팹리스 반도체 회사 매출 순위

Ranking	Fabless	Nationality	Revenue		Market Share	
			3Q22	2Q22	3Q22	2Q22
1	Qualcomm	U.S	$9,904M	$9,378M	26.5 %	23.8 %
2	Broadcom	U.S	$6,936M	$6,492M	18.6 %	16.4 %
3	NVIDIA	U.S	$6,093M	$7,086M	14.9 %	16.6 %
4	AMD	U.S	$5,565M	$6,550M	14.9 %	16.6 %
5	MediaTek	Taiwan	$4,675M	$5,290M	12.5 %	13.4 %
6	Marvell	U.S	$1,531M	$1,494M	4.1 %	3.8 %
7	Realtek	Taiwan	$979M	$1,036M	2.6 %	2.6 %
8	Novatek	Taiwan	$643M	$1,069M	1.7 %	2.7 %
9	Cirrrus Logic	U.S	$541M	$394M	1.4 %	1. %
10	Will Semi.	China	$513M	$691M	1.4 %	1.8 %

Table 1 shows the global fabless semiconductor firm sales rankings by a quarterly of quarterly in 2022. The US, Taiwan, and Chinese fabless firms occupy the ranking. Taiwanese fabless firms have MediaTek in fifth place, Realtek in seventh place, and Novatek in eighth place. Historically, there has yet to be a record of a Korean fabless firm entering the top 10 in the ranking. The development of the Korean fabless industry is more urgent than ever despite its position as the world's second-largest semiconductor producer [4].

Korea's semiconductor industry is relatively weak in the system semiconductor field, focusing only on memory semiconductor production centered on global firms such as Samsung Electronics and SK Hynix. That is why it constantly enhances the semiconductor ecosystem, such as fabless (design), foundry (manufacturing), and package(OSAT). It is necessary to prepare detailed support policies such as strengthening ecosystem capacity, expanding R&D support at the government level, and supporting the commercialization of small and medium-sized enterprises [6].

2-2 Background

Previous study for developing the Korean fabless semiconductor industry was conducted regarding marketing capabilities, government policies, CEO capabilities, and human resource. Table 2 shows the problems status, from the customer view of fabless, Korean electronic firms have global competitiveness such as Samsung electronics and LG electronics. The Korean fabless firms already proven with mass-production records on those firms. It means they have no problem entering foreign electronics firms regarding technology side. However, from a marketing point of view, they mainly focus on domestic mobile firms without oversea promotion for electronic firms [7].

From the government policy perspective, the Korean government actively intervened in the market to improve memory semiconductor competitiveness, promoting the merger between LG Semiconductor and Hyundai Electronics and promoting technology-leading policies centered on large firms. There is a need for more experts in the fabless semiconductor industry [8].

Table 2. Problem Statement of KoreaFabless Industry
표 2. 한국 팹리스 산업의 문제점 현황

Fabless view	Business Status	Problems
Customer	Focused on Domestic Set firms	Lack of Globalization
Marketing	Focused on Mobile Application	Domestic Inbound
Government	Conglomerate-oriented Policy	Absense of Fabless Experts
Human Resource	Absence of experts and Frequent TurnOver	Need constant motivation
CEO	IPO Target	Missing the Target after IPO

In terms of human resources, an essential condition for a start-up to achieve successful results in the fabless semiconductor business, and that people who have experienced innovative work in previous firms are more likely to perform innovative tasks [9].

From the CEO's point of view, most fabless CEOs expand their business, intending to list on the stock market through IPO (Initial Public Offering), an initial public offering for listing on the Korean stock market (Kosdaq). After listing on the stock market, there are limits to continued growth. are doing [10].

2-3 Blockchain and Smart contract Concept

Blockchain was first conceptualized by Satoshi Nakamoto in 2008 and then concretized for the digital cryptocurrency as

Bitcoin [11]. Blockchain is a distributed database that stores a continuously increasing data with chain of blocks[12]. Blockchain is a technology that distributes the authority for transaction recording and management to a P2P network composed of participants(Peers) and records/manages in units of blocks (nodes), and is decentralized rather than centralized like existing systems[13]. All transactions are stored in participating blocks (nodes) and managed by each participant (peer), enabling mutual reliability verification, certification, recording, and auditing of all records. They are also called public transaction ledgers or ledgers. Fig. 3. compares the existing centralized and decentralized systems of blockchain [14].

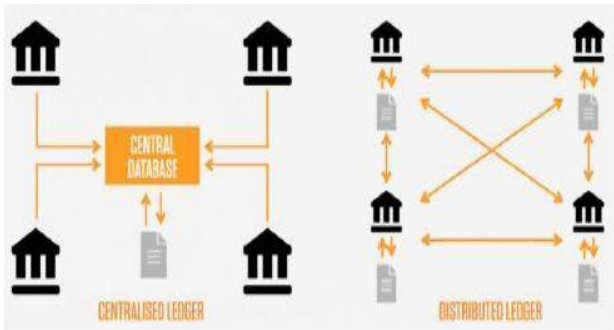


Fig. 3. Centralized Ledger vs. Distributed Ledger
그림 3. 중앙집권형 거래 vs. 분산화형 거래

The blockchain is a vast open network divided into a public blockchain that anyone can participate in the network and a permission blockchain that requires permission to participate in the network. The permission blockchain classifies into a private blockchain operated within the same organization by a single firm and a consortium blockchain jointly operated by several trusted participating firms that meet the participation conditions [15].

It could be done through smart contracts and digital commands that operate the blockchain, and there has yet to be a unified definition of smart contracts. Regarding various definitions of smart contracts, in the term of first conception founded by Nick Szabo (1997), who defined smart contracts as "a computerized protocol that executes the terms of a contract." In addition, traditional contracts are written in writing, and to fulfill the contract's terms, a natural person has to perform the contract basedthe contract. However, a smart contract written as a digital command contract can automatically execute the contents according to the program-coded conditions[16].

2-3-1 Blockchain in semiconductor industry

Blockchain technology and smart contracts have proven capable of creating and empowering self-sustained business models that can withstand supply chain uncertainties and environmental adversities. Development and application of modern smart tools can enhance domain-specific expertise and dedicated technology-driven working platforms within the digital supply chains[17].

Recently, due to the severe distribution of counterfeit semiconductors, as a solution to prevent duplicates, a blockchain was used to generate a unique hash value during production to suggest a method that cannot be duplicated[18].

In order to improve the production efficiency of the semiconductor manufacturing line, a study was presented to prevent the same mistake in advance by sharing real-time defect history through blockchain[19].

As a digital improvement work to increase the efficiency of using hundreds of robots in the semiconductor manufacturing process facility, a study was conducted to increase the utilization of virtual fabrication facility facilities using blockchain[20].

Ⅲ. Smart contract-based blockchain business of semiconductor industry

3-1 Background of blockchain adoption in the semiconductor

Most fabless firms in Koreaare small and medium-sized enterprises, and their growth is currently at a standstill. Suppose the Korean semiconductor industry is the most vulnerable and isolated compared to the United States, Taiwan, and Japan. In that case, a strategy to strengthen R&D in the value chain field and diversify technologies to stabilize the supply chain[21]. In a survey of 30 Korean fabless semiconductor CEOs, the biggest challenge to overcome for global fabless firms to emerge in Korea was the inability to advance into the global market[22].

In the semiconductor industry, Set firms requires the product development through close collaboration relationship with and fabless firms with strict-security contracts. Generally, Set firms are preferred to develop exclusively fabless firm for sustainability maintain product competitiveness.

In particular, representative set producers in each continent are promoting the establishment of a supply chain with domestic fabless firms as much as possible to establish a close cooperation system and agile business discussion. As a results, most fabless of korea, specializing in smartphones, white goods, and automobiles applications. In Japan, fabless firms

specializing in cameras, game consoles, and automobiles. In Europe, automobile-related fabless firms have developed[23].

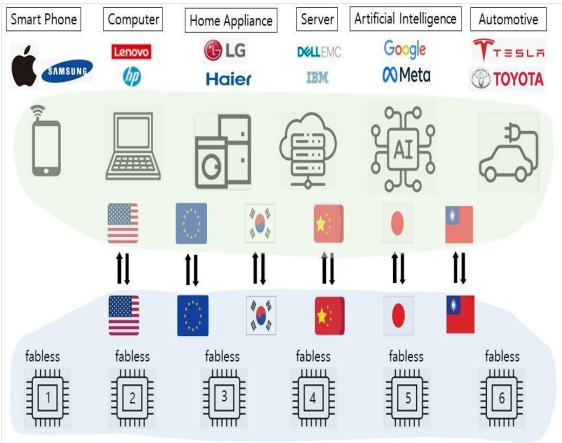


Fig. 4. Set firm and fabless cooperation status by regions
그림 4. 세트 회사와 팹리스사간 지역별 협업

Growth of the fabless business model is predicated on the ability of firms to produce quality goods a efficient scale[24]. Fabless firms are not limited to specific application groups, and if they can make products with good technology, they can apply them to all electronic devices to expand their business. This phenomenon gives many opportunities to domestic firms that are relatively easier to access than foreign firms in discovering new firms in the purchasing and development teams, which determine semiconductor parts in set firms. So, set firms in the US, Korea, EU, China, Taiwan, and Japan faced a situation where the semiconductor industry developed in line with the characteristics of competitive set firms in each country.

3-2 Consortium blockchain concept in semiconductor business

Depending on the purpose of use, the blockchain is classified as a public blockchain where anyone can become a transaction prover, a consortium blockchain where transactions are made only by pre-agreed rules and traders, and a private blockchain accessible only to authorized users[25].

Security is emphasized so that only authorized participants can access the blockchain and cannot view unrelated contract details. In the consortium blockchain, blocks are automatically created when the rules within the consortium are satisfied, and anyone can participate if they meet the block operating conditions[26]. A smart contract is a code realized based on a block chain and guarantees that the contents of the contract are automatically executed when pre-determined conditions are satisfied[27].

In the semiconductor industry, fabless firms check the possibility of new businesses with those advantages in consortium blockchain. Even though fabless firms have product competitiveness, they need to be provided with timely business opportunities due to limitations in regional and human networks and many restrictions on business expansion. Due to complex and sophisticated semiconductor structures and development difficulties, set firms must establish a system that can always collaborate with at least 3 to 4 competitive fabless firms to select the optimal parts in terms of technology, price, and quality.

Fig. 5. shows the engagement of competitive fabless parts suppliers for a specific application group, it is necessary to form a semiconductor vendor pool that can identify new fabless firms and business opportunities by forming a corporate consortium blockchain with restrictions on security and accessibility.

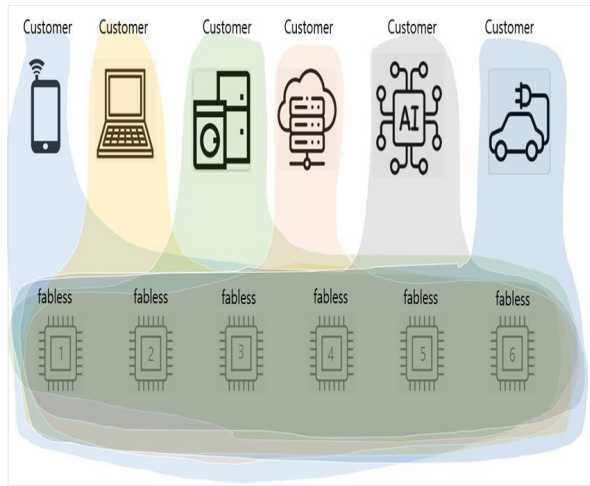


Fig. 5. Fabless vendor pools in consortium blockchain t
그림 5. 팹리스 업체 연합의 컨소시엄 블록체인

This consortium blockchain concept allows Korean fabless semiconductor firms lacking human resources or funds to break away from the traditional business structure of specific application groups in their country and be allowed to enter new businesses with set firms in various application groups. In particular, it is a new solution for business opportunities in emerging technologies such as self-driving vehicles and AI (Artificial Intelligence)-based servers semiconductor markets, where infrastructure is a weak field.

Ⅳ. Smart contract-based business model proposal

4-1 New business model flow chart

In most semiconductor component selection processes, fabless get a new business chance when they explain the excellence of its products through the purchasing and research department of the set firm and receives approval from two teams simultaneously. However, most set firms are developing new products through collaboration with current fabless partners. In order to get a new business chance, fabless must get an approval from the purchasing and R & D department, but if the department in charge of the set firms does not review the feasibility of new supplier, it is a harsh environment for the new business chance.

To reach the mass production stage, fabless firms must undergo many verification steps. However, set firms have limited opportunities to offer new fabless due to a lack of human resources. If such a situation continues, it will be difficult to obtain new business opportunities. Therefore, this study proposes a new business model called F-SBM (Fabless-Samrt contract based Blockchain Model) to create opportunities fairly for new fabless to receive business chance.

Fig. 6. compares the business flow chart with traditional semiconductor selection process and the new business model as F-SBM.

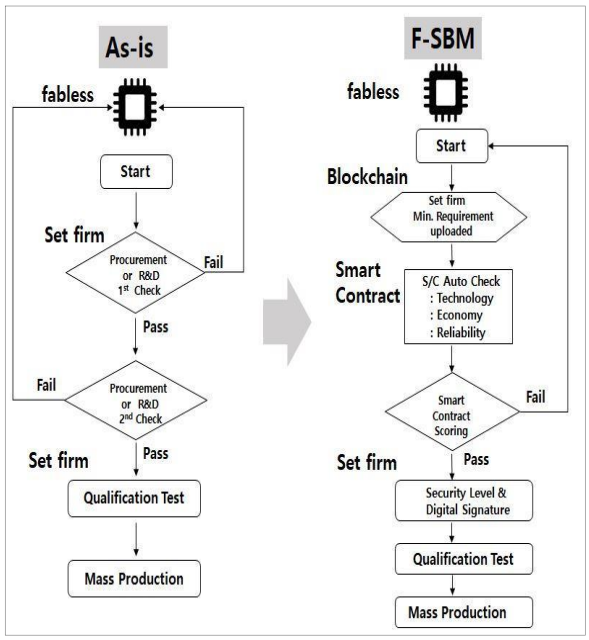


Fig. 6. F-SBM Semiconductor Business flow chart
그림 6. F-SBM 반도체 거래 flow chart

The F-SBM business platform presented with smart contract based blockchain flow chart. In F-SBM flow chart, fabless firm is not need to promotion through a direct purchasing department and R&D department to secure new business opportunities as before. When a set firm as customer, first receives the business procurement request from the fabless firm, it reviews the information first. Set firm provides the grants the qualification to apply to the blockchain if it is suitable. The semiconductor specifications to be applied to the new model are coded into a smart contract and transmitted to the blockchain through the transaction. Afterward, when a product registration transaction occurs, product registration information and blocks are created and shared with all participant nodes on the network. Then, breaking away from the traditional semiconductor SCM structure, the consumer, the set firm, can automatically verify the business suitability of the supplier, the fabless firm, in a Smart contract based Blockchain.

This model gives equal opportunities to small fabless companies that are semiconductor suppliers, enabling transparent transactions and enabling transparent competition among the qualified companies in the blockchain network.

4-2 New business model framework

In the semiconductor business, set firms' built a cooperative relationship with a dedicated fabless partner. In addition, set firms can improve their system competitiveness by receiving high performance semiconductors by providing opportunities to all firms reasonably to secure competitive semiconductors. Set firms want to engage competitive new fabless firms, but there are many limitations in human resources and verification methods. They are always concerned about how to maintain the security of semiconductor information. This study suggests the workflow of the F-SBM model proposed below.

To describe the detailed model workflow, First, based on the consortium blockchain, the person in charge of the set firm checks the essential information for minimum requirement information in the fabless firm. The person in charge of the set firm confirms the minimum information provided and then, the suitability is automatically judged through the smart contract. In a smart contract, in order to check the competitiveness of new semiconductor fabless firms, firms that have obtained the minimum required score for each item based Technology, Economy, and Reliability conditions and smart contract is automatically notified to fabless and set firms and full-scale

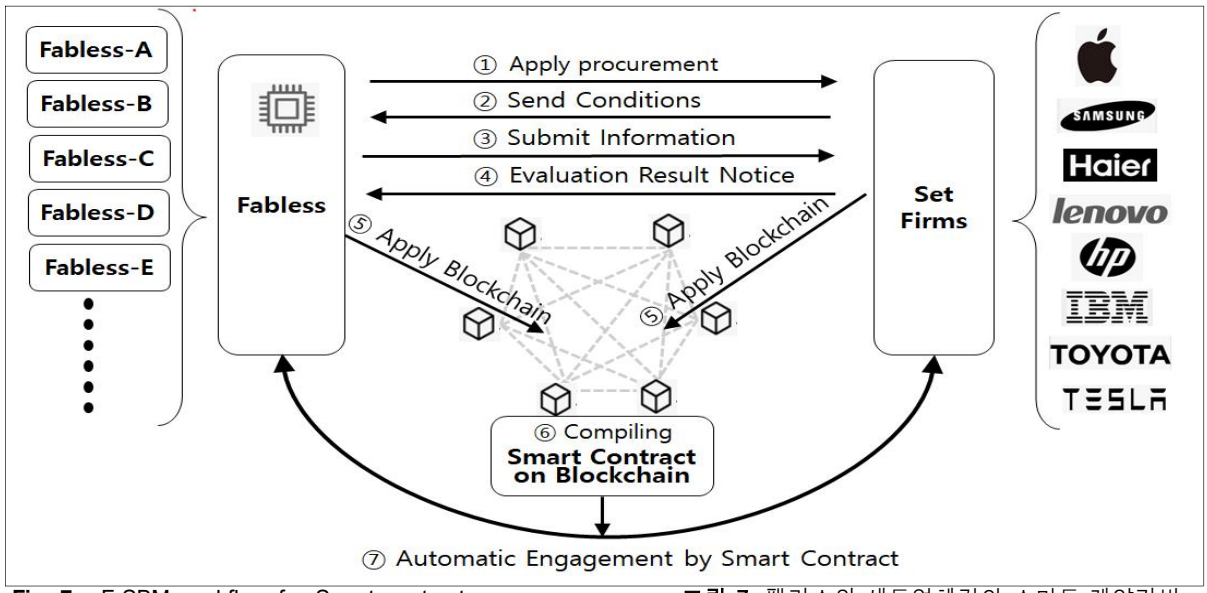


Fig. 7. F-SBM workflow for Smart contract basedBlockchain Business flow with Fabless and Set firms

그림 7. 팹리스와 세트업체간의 스마트 계약기반

business negotiations are held and then can start. Afterward, after checking the detailed items requested by the set maker and going through the quality team's verification, it proceeds to the mass production stage if there are no problems.

Fig. 9. shows the F-SBM framework for applying new semiconductor parts between fabless and set firms, and the sequence of scenarios is as follows.

① Fabless firms support bidding for semiconductors to set firms.

② set firms provide the conditions for adopting the new semiconductor parts.

③ The fabless firm provides information corresponding to the conditions requested by the set firm.

④ The person in charge of the set firm checks whether or not there is an error in the information provided by Fabless and delivers the conformity of the provided information.

⑤ After checking the consistency of the results, the fabless and set firms upload their respective information to the blockchain.

⑥ Based the information provided by the fabless and set firms, the smart contract is executed to determine whether the conditions are satisfied.

⑦ If the conditions of the smart contract are satisfied, set firms and fabless firms automatically sign the MOU contract

Through this new business model, when fabless firms get a new business opportunity through blockchain, authorized users through a consortium blockchain that can only be supported by the the fabless firm becomes a notice of the support situation, and the set firm sends essential evaluation items to the blockchain in consideration of the performance of the semiconductor parts required for the model.

In consortium blockchain, a smart contract is automatically executed based the information provided by the fabless firm and the information requested by the set firm. It informs whether the fabless firm is approved for the contract terms. Then, for the qualified fabless firms, it is disclosed which firms were approved and which failed while maintaining fairness and transparency in the transaction stage. Approved fabless firms automatically sign MOU (Memorandum Of Understanding) with set firms to discuss the possibility of commercialization in detail. Fabless firms can secure many business opportunities with set firms through F-SBM while reducing time and effort, escaping from promoting business opportunities through the purchase team or development team of some set firms through the existing limited network.

4-2 New business model configuration

In the semiconductor business of set firms, they want to maintain continuous supply transactions with firms whose performance has been verified. It takes time and security to enter and select new firms. So, to first confirm the competitiveness of the baseline fabless firms, the verification items of the firms participating in the consortium blockchain-based network are composed of technology,

economy, and reliability conditions.

The first stage, Baseline Level, is intended to evaluate and list the competitiveness of firms at a general level and to create an open platform in that anyone can participate by forming a consortium blockchain and provide openness and fairness to supply semiconductors with performance suitable for various application groups on time. The goal is to discover competitive fabless firms in terms of evaluation criteria.

This step corresponds to level 1 of the consortium blockchain, and if the firm has only essential competitiveness, Smart contract will be automatically compiled. If only the minimum required specifications are satisfied in each technology, economy, and reality category, it is automatically connected to the blockchain and receives a level 1 security level. Then, through smart contracts, fabless firms are automatically listed on the blockchain network when the competitiveness required by set firms is approved. Afterward, firms that have passed the level 1 stage need to be verified in the level 2 stage. In this part, the purpose of this part is to check the actual performance from the perspective of semiconductor components to which set firms apply new components.

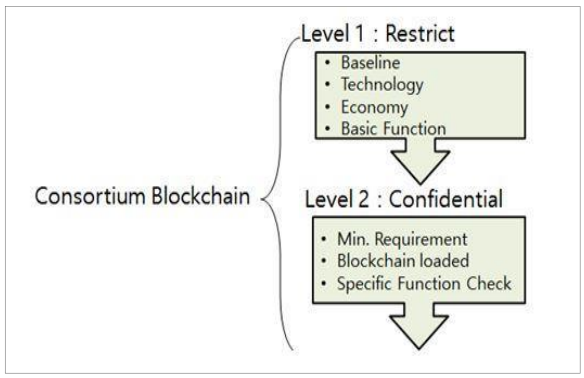


Fig. 8. Security Level of Consortium Blockchain Business
그림 8. 컨소시엄 블록체인 거래의 보안 등급

After compiling the basic baseline information of Level 1 through the set firm practitioners in the consortium blockchain, the competitiveness be verified in terms of Technology, Economy, and reliability. The weight for each item is 50% considering the characteristics of semiconductor parts, 30% for the economy part, and 20% for the reliability part. Thus, a smart contract is automatically created and uploaded to the blockchain if a score of 90 or more is scored based the table conditions.

In the table 3, the fabless firm provides information that meets the firm's standards for each item on the blockchain and automatically compiles the smart contract algorithm to level 1. After passing the Level 2 stage, Fabless and Set firm automatically sing the MOU on smart contracts.

The consortium blockchain is divided into three upper categories, and then sub-evaluation items of the detailed items are created. If the total score given the proposed weight is 90 points or more, the firm passes the first stage and gives conditions to be verified on the Consortium blockchain.

In Korean fabless cooperation with set makers, essential items were analyzed by R&D, unit price, and order quantity that needs improvement related to semiconductor business and contracts [28]. This study selected configuration items of smart contracts with Technology, Economy, and reliability categories regarding development cooperation, unit price, and supply items.

Table 3. Smart contract configuration and weight conditions
표 3. 스마트계약 구성 및 가중치 항목

Category	Criteria	Index	Score	Weight
Technology	Patent Number	≥ 20	30	50%
	R&D Engineer Portion	≥ 60%	30	
	Development Period (Month)	≤ 12M	20	
	Foundry Process Engineer (People)	≥ 5	20	
Economy	Company Sales Revenue (3yrs Avg)	≥ $100M	30	30%
	Company Operation Income(3yrs Avg)	≥ 25%	30	
	Total Assets	≥ $50M	20	
	Investment Deposit (3yrs)	≥ $10M	20	
Reliability	PPM ratio	≤ 6 PPM	30	20%
	Mass Production	≥ 10Mea	30	
	Local dedicated Field Support	≥ 5people	20	
	Foundry & OAST Counterpart	≥ 2 site	20	

Technology items are divided into the development period and foundry process engineer retention based the number of patents, the ratio of research personnel, and the semiconductor specifications of set firms. Among each item, the number of patents and the ratio of engineers were given high weights to determine technological prowess. The highest weight was given in the initial verification stage to give opportunities to fabless firms with more technological prowess than other items.

The Economy category evaluated sales, operating profit, investment, and total assets for the last three years. The firm's business capability and mass production history can be evaluated through sales and operating profit rates for the last three years, and the value of technology possession can be evaluated through investment amount. Among them, sales and operating profit ratios were given high scores to evaluate current sales capabilities.

The Reliability item was evaluated by the defective rate of mass-produced products, mass-production history, technical support and foundry, and OSAT(OutSourcing Assembly Test)

items. The ability to operate in multiple places was evaluated as an item. Then, based the information, it is coded based smart contract software and checked for suitability. Next step, the information provided by fabless at the time of application is stored through the blockchain and shared with the set firm－the resulting notice if it passes the verification through the smart contract.

```
// Define F-SBM Pseodu-code:
  function RegisterTermsOnBlockChain(Fabless, Setfirm) {
    // Register terms on BlockChain using Setfirm as the firm  }

function reviewBiddingInfo(Setfirm, Fabless) {
  // The person in charge of Setfirm reviews Fabless' bidding
information in advance}

function preReview(Setfirm, Fabless) {
// Conduct a pre-review and provide transaction terms if
requirements are met}

function provideTransactionTerms(Setfirm, Fabless) {
// Provide transaction terms to Fabless}

function provideRequestedInfo(Fabless, Setfirm) {
// Fabless provides the requested information to Setfirm}

function evaluateBusinessFeasibility(Setfirm) {
// Evaluate and inform business feasibility}

function checkSemiconductorApplicability(Setfirm) {
// Check the applicability of new semiconductors through smart
contracts on BlockChain}

function conditionsSatisfied(Setfirm) {
// Check if the conditions of a smart contract are met}

function grantTransactionRights(Setfirm, Fabless) {
// Automatically grant transaction rights}

function calculateFinalScore(Setfirm) {
// Calculate the final score by weighing each criterion (Technology
, Economy, and Reliability)}

function signMOU(Fabless, Setfirm) {
// Sign an MOU between Fabless and Setfirm}

function failProcess() {
// Execute the process as a fail if the final score is less than
90}

// Main program:
RegisterTermsOnBlockChain(Fabless, Setfirm)

while (true) {
reviewBiddingInfo(Setfirm, Fabless)
if (preReview(Setfirm, Fabless)) {
provideTransactionTerms(Setfirm, Fabless)
provideRequestedInfo(Fabless, Setfirm)
evaluateBusinessFeasibility(Setfirm)
checkSemiconductorApplicability(Setfirm)
if (conditionsSatisfied(Setfirm)) {
grantTransactionRights(Setfirm, Fabless)
break
}
}
}

if (calculateFinalScore(Setfirm) > 90) {
signMOU(Fabless, Setfirm)
} else {
failProcess()
```

Fig. 9. F-SBM Smart contract Pseodu-code algorithm
그림 9. F-SBM 스마트 계약 Pseodu-code 알고리즘

Fig. 9 shows, it is a pseodu code algorithm that executes smart contracts. Each technology, economy, and reliability items are scored, and detailed items such as patent and development period are weighted and executed. If the conditions for each item are not met, a False is returned, and if the conditions are satisfied, it is a command as a True value. Scores are obtained based 100 points by the weight ratio defined in each category. In the result, if the final score exceeds 90, it is a pass condition; if the score is less than 90, it is executed as a fail.

Ⅴ. Verification (F-SBM)

5-1 Paired samples T-test

In this study, a paired t-test was simulated to analyze the differences before and after results a specific variable in the sample to verify the practicality of the Smart contract based Blockchain transaction model. Paired sample t-test is used to analyze paired data with one population and for pre- and post-comparison verification of the same group. The following t-test statistic is used to test the difference between paired values.In this case, d = represents the average value of the difference between the values of each sample element, △o = represents the average value of the difference set as a null hypothesis, and Sd = represents the standard deviation of the different values of the sample elements.

$$t = \frac{\overline{D} - d_0}{S_D / \sqrt{n}} \quad , \quad \overline{d} = \frac{\sum_{i=1}^{n} d_i}{n}$$

$$s_d = \sqrt{\frac{\sum_{i=1}^{n}(d_i - \overline{d})^2}{n-1}} = \sqrt{\left[\sum_{i=1}^{n} d_i^2 - \left(\sum_{i=1}^{n} d_i\right)^2 \Big/ n\right] \Big/ (n-1)}$$

Fig. 10. Paired Samples t-test statistical verification equations
그림 10. 대응 표본 t-검증 통계검증 방정식

The fabless firm confirmed the difference in the number of products developed for a new set of customers before and after applying the Smart contract based Blockchain model through inference. The subjects were inferred baseddomestic fabless firms. A paired T-test was conducted through SPSS Statistics 27 to determine if there was a difference in the number of products developed before and after applying blockchain to 10 domestic fabless firms.) was performed, and the statistical significance level was set at α=.05.

5-2 Verification result

Fig. 11. shows, it testing the matched sample T verification of the average number of new products developed by fabless firms before and after implementing the Smart contract based blockchain model that the average number of new product

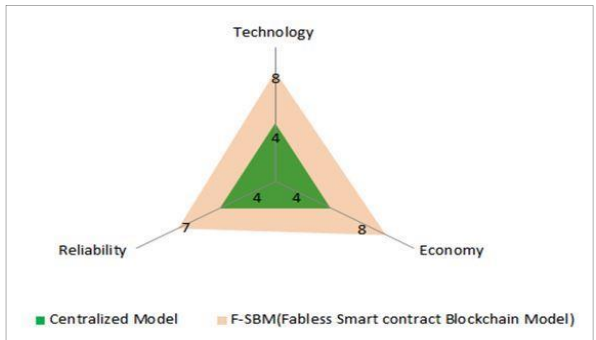
developments before applying the model was 6.6. The average number of new product developments after applying the model was 11.0, a preliminary preparation. It shows a difference of -4.40. Since the t value is -19.000 and the significance probability t value is smaller than p<.05, it checked that the adoption of the Smart contract based blockchain model significantly affects the expansion of new fabless businesses and average product development.

		평균	N	표준편차	평균의 표준오차
대응 1	Before	6.60	10	1.578	.499
	After	11.00	10	1.944	.615

		대응차							
		평균	표준편차	평균의 표준오차	차이의 95% 신뢰구간 하한	상한	t	자유도	유의확률 (양측)
대응 1	Before - After	-4.400	.699	.221	-4.900	-3.900	-19.900	9	.000000009

Fig. 11. F-SBM adoption before and after with t-test results

그림 11. F-SBM 적용전후 t 검증 결과



Decision Items	Weighting	Centralized Model	F-SBM	Decision Items	Weighting	Centralized Model	F-SBM	Decision Items	Weighting	Centralized Model	F-SBM
Technology Category	0.50	0.44	0.83	Economy Category	0.30	0.40	0.80	Reliability Category	0.20	0.41	0.73
Patent Number	0.30	0.40	0.65	Sales Revenue	0.30	0.35	0.80	PPM Ratio	0.30	0.35	0.80
R&D Portion	0.30	0.35	0.80	Operation Income	0.30	0.30	0.75	Mass Production	0.30	0.35	0.65
Development Period	0.20	0.45	0.80	Assets	0.20	0.45	0.65	Field Support	0.20	0.45	0.75
Process Engineer	0.20	0.55	0.65	Investment Deposit	0.20	0.50	0.80	External Partnership	0.20	0.50	0.70

Table 4. Centralized Model vs. F-SBM for Technology, Economy, Reliability simulation results

표 4. 중앙 집권형 및 F-SBM 의 기술성, 경제성, 신뢰성 시뮬레이션 결과

The traditional semiconductor application methods can confirm expected results that are improved for semiconductor items compared to the existing ones in terms of centralized model and Smart contract based Blockchain Model (F-SBM). Table 4 also predicts improved effects compared to the existing ones in terms of technology, economy, and reliability when the F-SBM model is applied compared to the traditional semiconductor component application method.

This verification has proven the effectiveness of new markets and customer expansion for the growth of Korean fabless system semiconductors.

Ⅵ. Conclusion

6-1 Conclusion

Over the past 25 years, the Korean semiconductor industry has moved away from memory semiconductors and emphasized the growth of system semiconductors and the development of fabless companies. However, it has continued to fail. Several previous studies have analyzed the problems in government policies, lack of human resources, and cooperation growth between fabless and set firms. However, Korean system semiconductors are still in recession.

In this regard, this study is the first in the industry with fabless to apply Smart contracts based consortium Blockchain Model to the semiconductor component selection process, and the detailed conditions of smart contracts to evaluate the competitiveness of actual fabless firms are classified from the viewpoints of Technology, Reliability, and Economy. It was classified, and detailed evaluation items for each category were defined to present a transaction model applicable to the semiconductor industry. With this research as an opportunity, not only fabless firms but also electronic equipment set firms can build a system that can be applied to enhance the performance of their products at any time by establishing a permanent pool of competitive fabless firms through this business model.

Therefore, through the application of the new business model presented in this study, the critical issue in the growth of the Korean system semiconductor industry is the failure to enter the global market and expand the number of new product development, and cannot escape the structure of mass production only by domestic set makers. Therefore, this study has presented a practical solution as a new business model(F-SBM) verified the effectiveness of the unique opportunity to enter the global market business.

6-2 Further research

A future study presented a Smart contract based Blockchain business model for fabless semiconductor firms to apply semiconductors to new models of set firms. For actual semiconductor adaption, a varity types of semiconductors are

embedded in electronic devices, so it is not easy to set a specific semiconductor device as a part that can be automatically traded through Smart contracts. Since more than 100 types of semiconductors are applied to electronic devices, which parts are actually applied, it takes work to share, even for limited firms. Therefore, it is necessary to select semiconductor components applicable to the actual set of devices. In addition, it is necessary to present a smart contract implementation algorithm through a private blockchain that requires a high level of security in the consortium blockchain established in the initial stage of this study.

Additionally, further studies need to more feasible weighted items based on legal grounds and regulations to apply the smart contract-based semiconductor business model to Korean fabless companies. In addition, there is a need for a detailed feasibility study on the security and reliability side when this business model adapts to the Korean semiconductor industry.

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