Master's Science in Engineering

System Dynamics Approach for Construction Labor Productivity Analysis Focusing on Social Influence

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Abstract

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Construction Labor Productivity is a significant index directly related to profitability of the industry. Since construction is a highly labor intensive industry, the importance of labor productivity is remarkable. Though the technology level in Korean construction industry is high, productivity appears to be low. Besides, the annual productivity in construction industry shows high fluctuation. High fluctuation can result in low average productivity which causes low profitability of the project.

For these reasons, worldwide studies are performed in various methods to explain and improve Construction Labor Productivity. Important part of these studies is deriving Influential Factors and verifying their effects. Also,

regarding this construction labor productivity as a complex social phenomenon, often System Dynamics approach is conducted to explain and simulate the Productivity in construction.

This study focuses on explaining both low productivity level and intense annual fluctuation of productivity. A System Dynamics model is built at macro level concerning social influences on Labor Productivity. By analyzing the model, this study describes an approximative influence of social factors to Construction Labor Productivity.

Keyword : Construction labor productivity, Productivity loss, Productivity Fluctuation, Social influence, Macro scope, SD (System Dynamics)

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Chapter 1. Introduction

1.1. Research Background

Labor productivity issues are receiving increasing attention within the construction industry (Allmon et al. 2000; Teicholz 2001). This should not be a surprise, as labor productivity is one of the best indicators of production efficiency. Higher productivity levels usually translate into superior profitability (Rojas et al. 2003).

Construction is a highly labor intensive industry. Site workers account for up to 40% of the direct capital cost of large construction projects and there is a need to maximize the productivity of labor resources (Ng et al. 2004). Considering this, Construction Labor Productivity (hereinafter referred to as "CLP") has a significant role as an influence factor to profitability in construction industry.

CLP is a ratio of Labor input and Output. This index classifies among the measures and forms of input and output. The measures used in this study is a Productivity index from Korean Productivity Center (Kpc), of which the formula is shown as follows.

$$Productivity\ index = \frac{Output\ (Industrial\ Production\ index)}{Labor\ Input\ (Workers\ \times Workhours)}$$

Since the Output (Industrial Production index) is composed of Profit of corresponding industry, it is concluded that CLP index can be used to evaluate the utility of an industry to national economy.

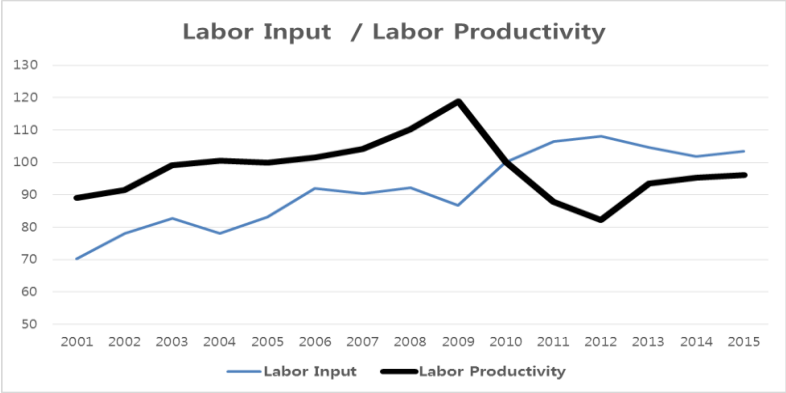


Figure 1-1. Time Series Productivity index in Construction industry (Kpc, 2001~2015)

As shown in Figure1-1, annual data of CLP in Korea (Kpc, 2001~2015) shows a huge fluctuation up to nearly 20%. Considering the size of the budget in construction industry, this could mean a serious economic loss.

In order to make Construction industry a valuable activity for national economy, reaching optimum productivity and keeping it in static position is important.

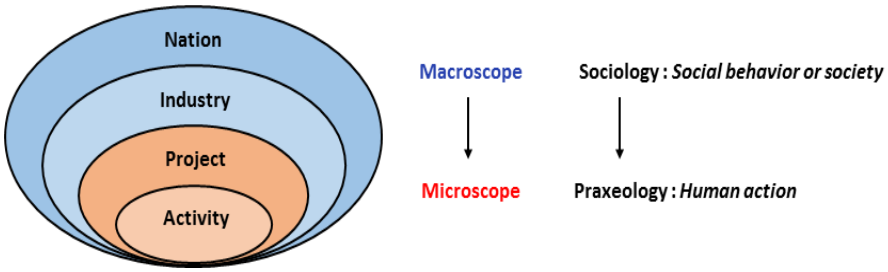


Figure 1-2. Leveling Framework for analyzing CLP research (Wen, 2014)

Because of this importance of CLP in construction industry, a worldwide researches are conducted to analyze and increase CLP. As figure 1-2 shows, one study by Wen in 2014 revealed that CLP studies can be classified to four levels; 1) Activity (Worker) Level, 2) Project Level, 3) Industry Level, 4) Nation (Society) Level. The upper the research level goes, the more 'Macro' the scope becomes. This leveling method is an application of the classification from Sociology, which study the social behavior and Praxeology, which study human action.

Conventional CLP studies focused on Activity Level (Micro level), searching for reasons of individuals' productivity loss and ways to improve it. This can be a valid approach at some appropriate scopes since the actual main agent of CLP are the workers. However, the purpose of this study is to explain annual fluctuation of CLP, which differ the scope from those Microscope studies.

The main goal of this study is to explain the annual CLP conditions. The scope of this index is at industry to nation level, which differs the scope from previous micro scope studies. In order to verify social influence to CLP, a macro scope approach should be more persuasive.

1.2. Problem Statement

In addition to the steady interest in improving CLP, annual data of CLP index in Korea shows a substantial fluctuation which might lead to severe profit loss in construction industry. This can be a serious problem because declined industrial competitiveness of Construction might cause not only intuitive problems as low index, but also social problems as unemployment due to low contracts. It occurs that maintaining certain productivity level is important for industrial maturity.

In order to reach and maintain optimum productivity, it is important to explain the causal relationships between CLP index and social influence factors.

Conventional micro level studies can be inappropriate to explain this phenomenon, in situation that the scale of the index is at industrial and national level. Larger scaled index needs a macro scope explanation with social influences.

1.3. Research Objective & Scope

This paper's objective is to analyze CLP at macro level. It is important to explain the reasons of both low productivity and intense annual fluctuation of CLP in Korea. For this purpose, a System Dynamics approach is made to build a qualitative model.

By using macro scope factors among Productivity Influential factors, it is possible to synchronize the scope of the purposed CLP index and the proposed model. Influential factors to CLP in this study are specified to several social influential factors.

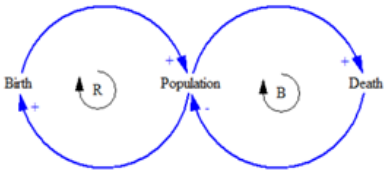
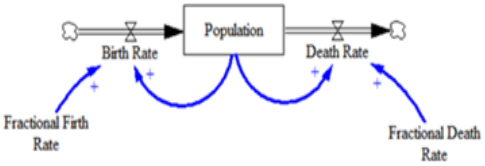
1.4. System Dynamics (SD)

System Dynamics (SD) is a sort of modeling method that have the advantage in presenting and understanding complex and dynamic system which contains various interactions and feedbacks. (sterman, 2000)

Basic principals in SD modeling is described as follows (Table 2-2). In the system dynamics methodology, a problem or a system (e.g., ecosystem, political system or mechanical system) is first represented as a causal loop diagram. A causal loop diagram is a simple map of a system with all its constituent components and their interactions. By capturing interactions and consequently the feedback loops (Table 2-2), a causal loop diagram reveals the structure of a system. By understanding the structure of a system, it becomes possible to ascertain a system's behavior over a certain time period. Causal loop diagrams aid in visualizing a system's structure and behavior, and analyzing the system qualitatively. To perform a more detailed quantitative analysis, a causal loop diagram is transformed to a stock and flow diagram. A stock and flow model helps in studying and analyzing the system in a quantitative way.

The goal of this paper is to understand the social influence on Industrial Construction Labor Productivity. Assuming that society is highly influential to CLP, this can be considered a complex social phenomenon, making it a reasonable choice to adopt System Dynamics methodology.

Table 1-1. Basic principals in System Dynamics Modeling

Causal Loop Diagram	**Stock and Flow Diagram**
By capturing interactions and consequently the feedback loops, it reveals the structure of a system	To perform a more detailed quantitative analysis, a causal loop diagram is transformed to a stock and flow diagram
	

1.5 Research Process

The order of this research is as follows (Figure 1-3). Introduction shows the definitions of CLP and problem of referred phenomenon.

Literature Review includes general CLP studies and various methods. System Dynamics (SD) methodology is introduced to explain the validity of this adoption. Previous System Dynamics approach to CLP studies are introduced to show the methods and logics among the variables.

Modeling goal is set to correspond to the purpose of the study. Process includes sets of logical basis and building Causal Loop Diagrams and Stock & Flow diagrams. Integrating sub models and social influence factors completes the model. Qualitative SD Model explains the influence of social factors to CLP.

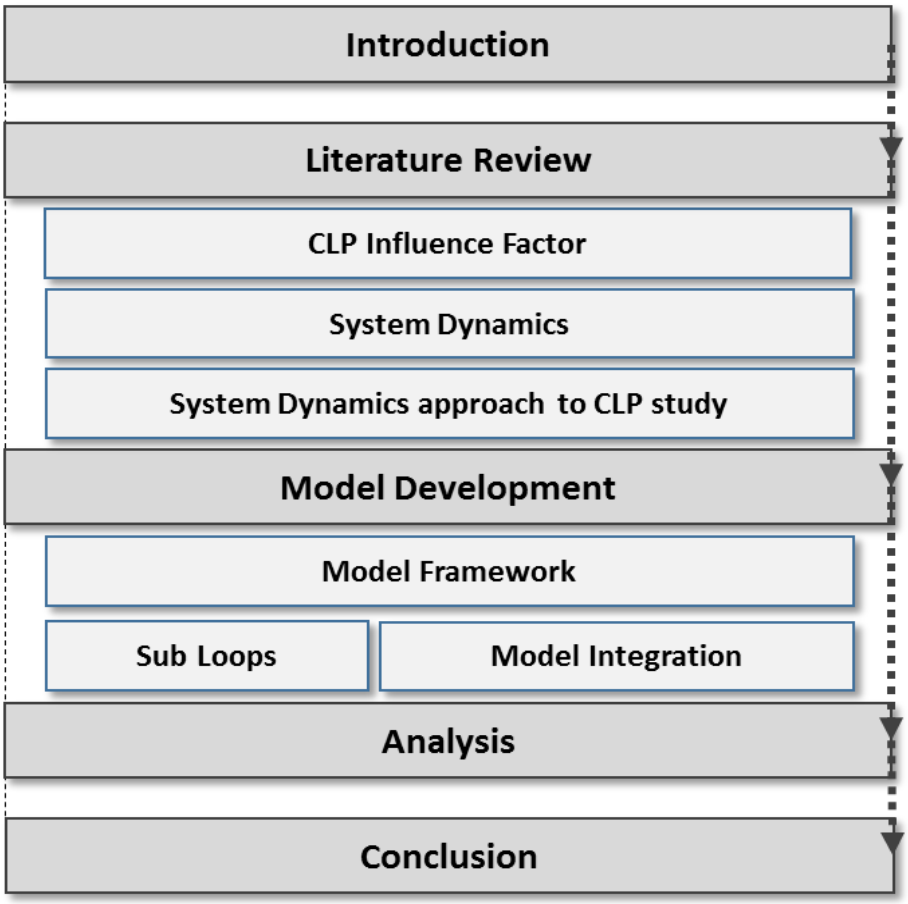


Figure 1-3. Research process

Chapter 2. Preliminary Study

In this chapter, contents of preliminary studies subjecting CLP are described. The purpose of this chapter is to derive the process and methods of studies with analogous goals.

In detail, preliminary studies show derivation of influential factors to detailed analysis on CLP. Then System Dynamics (SD) methodology is introduced. Last part is composed CLP studies with SD models.

2.1. Construction Labor Productivity Studies

The process of CLP studies starts from verifying influential factors to CLP. There has been lots of studies for this purpose, and following study arranged a series of CLP influential factors among historic studies as follows (Table 2-1).

Table 2-1. Series of Studies on Labor Productivity influence Factors

Author	Year	Factors
Lim and Alum	1995	lack of qualified supervisors
		shortage of skilled labor
		high rate of labor turnover
		labor absenteeism
		communication with foreign laborers
Zakari	1996	materials shortage
		weather and site conditions
		equipment breakdown
		drawing deficiencies/change orders
		lack of proper tools and equipment
Kaming	1997	lack of materials
		rework
		absenteeism of operatives

		lack of suitable tools
Alinaitwe	2007	incompetent supervisors
		lack of skills
		rework
		lack of tools/equipment
		poor construction methods
Dai	2009	tools and consumables
		materials
		engineering drawing management
		construction equipment
Kheirieh and Heravi	2010, 2011	weather
		management
		motivation
		incentives
		tools
		planning
		materials
Jarkas and Bitar	2012	clarity of technical specifications
		the extent of variation/change orders
		coordination level among design

		disciplines
		lack of labor supervision
		proportion of work subcontracted
		design complexity level
		lack of incentive scheme
		lack of construction manager's leadership
		stringent inspection by the engineer
		delay in responding to requests for information

From these series of studies, it is revealed that influential factors are diverse, however there occurs a commonness. Considerable portion takes microscope view, focusing into workers' status or project influential factors. Macro level factors are often undefined from previous studies.

This could be regarded as if the macro level influence to CLP is treated insignificant, however, Wen's study has shown its importance. Thus, the conclusion from this can be the lack of macro scope approach to CLP studies and it is required to make such analysis.

2.2. System Dynamics Approach to Construction Labor Productivity Study at Micro Level

System Dynamics as explained in previous chapter, is an appropriate tool to explain social system. This and the following chpaters contain CLP studies applying SD models. Previous studies introduce both qualitative and quantitative model to explain the purposed causal relations concerning CLP. In this chapter, a micro scope approach to CLP study is introduced.

Alvanchi(2012) performed a typical System Dynamic approach to a micro scope CLP study. Alvanchi built a SD model Focused on the effect of Workers' physical and mental fatigue on Productivity during dynamic workhours. (Figure 2-1, 2-2) This modeling process is rather scientific, adopting physical energy psychological status of the body. The result of the study is mainly about the effect of workload on the workers' productivity.

Not only in the work of Alvanchi, many proofs refer that workload to construction workers is a main cause of productivity loss. Taking this as a fact, the deficiency of construction workers and high workload can be a cause of general loss of productivity in construction industry.

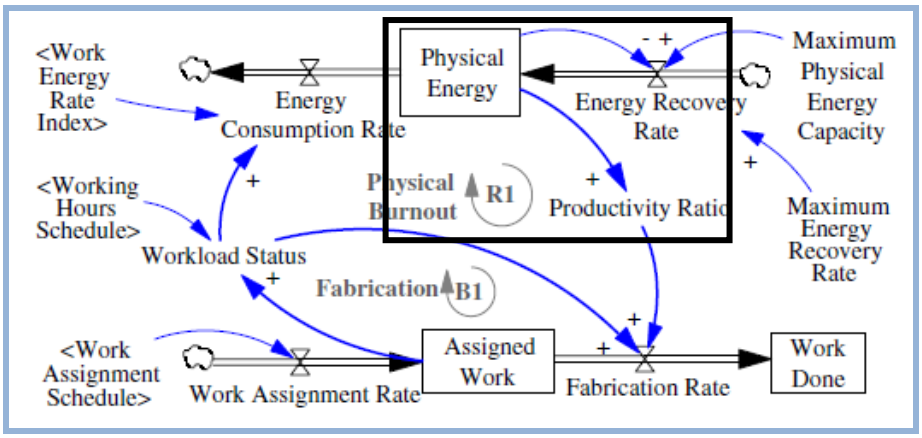


Figure 2-1. Dynamics of physical fatigue as a result of prolonged high physical involvement (Alvanchi, 2012)

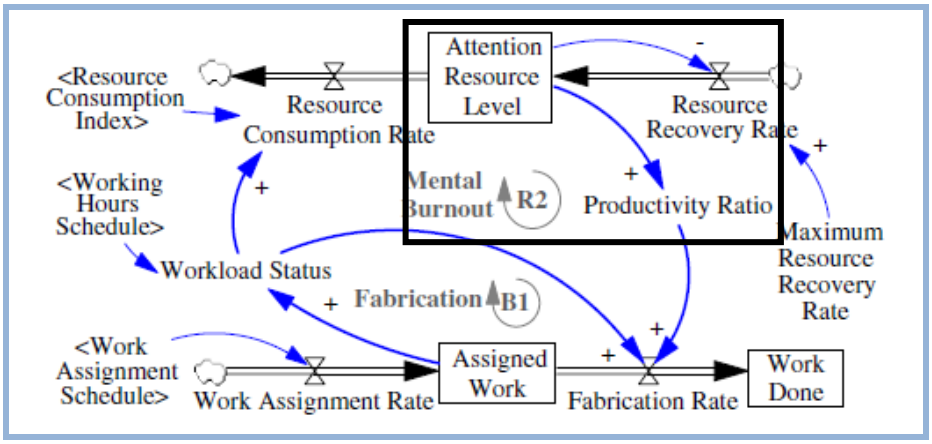


Figure 2-2. Dynamics of mental fatigue as a result of prolonged sustained attention (Alvanchi, 2012)

2.3. System Dynamics Approach to Construction Labor Productivity Study at Macro Level

The main attention of this study is the macro scope approach to explain CLP. Following studies, though the precise classification is not made, focused on rather macro influences on CLP.

Jang(2009) carried out a CLP study at relatively macro level influence. SD model connects population, wage, employee status and CLP as shown in following model (Figure 2-3).

As shown in the model, Jang estimates construction workers' feature (numbers, ability, age, …) and national role and efficacy of Construction to be the influential factors to CLP.

Though the logic between variables and the concerns are insufficient, this model has identical concept to this own paper. Thus, in this study tempt to adopt some ideas and logics as reference in modeling process. Influence of image to inflow rate and investment on R&D are adopted in the modeling process.

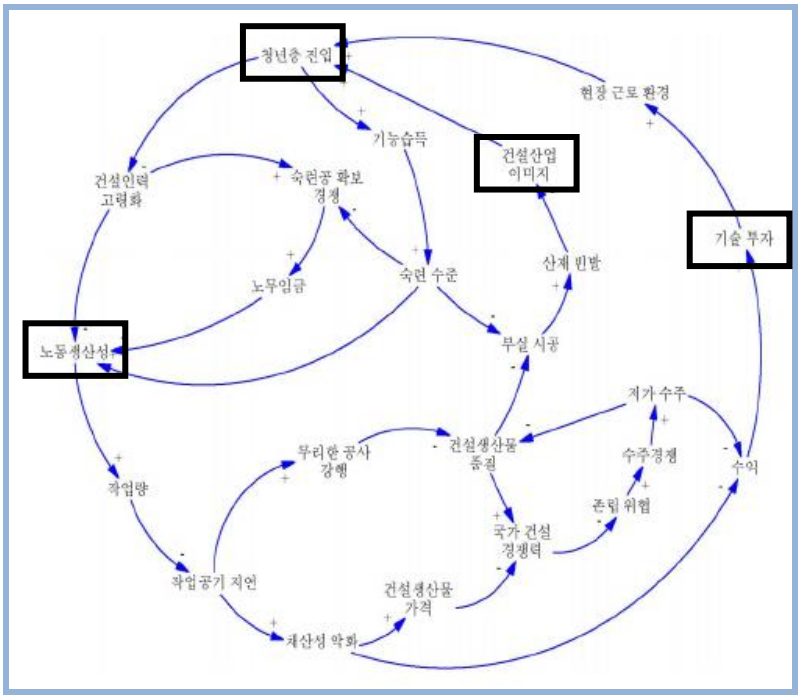


Figure 2-3. Causal Loop Diagram of Labor Productivity (Jang, 2009)

Nasirzadeh(2013) also conducted a system dynamics approach at macro level. Main framework of this preliminary study is the influence of government policy on CLP. Especially, labor policy from work hours to wages are concerned and shown in different sectors by SD models.

The relation of project cost and duration is as follows (Figure. 2-4). This logic between cost and duration is adopted in the modeling process.

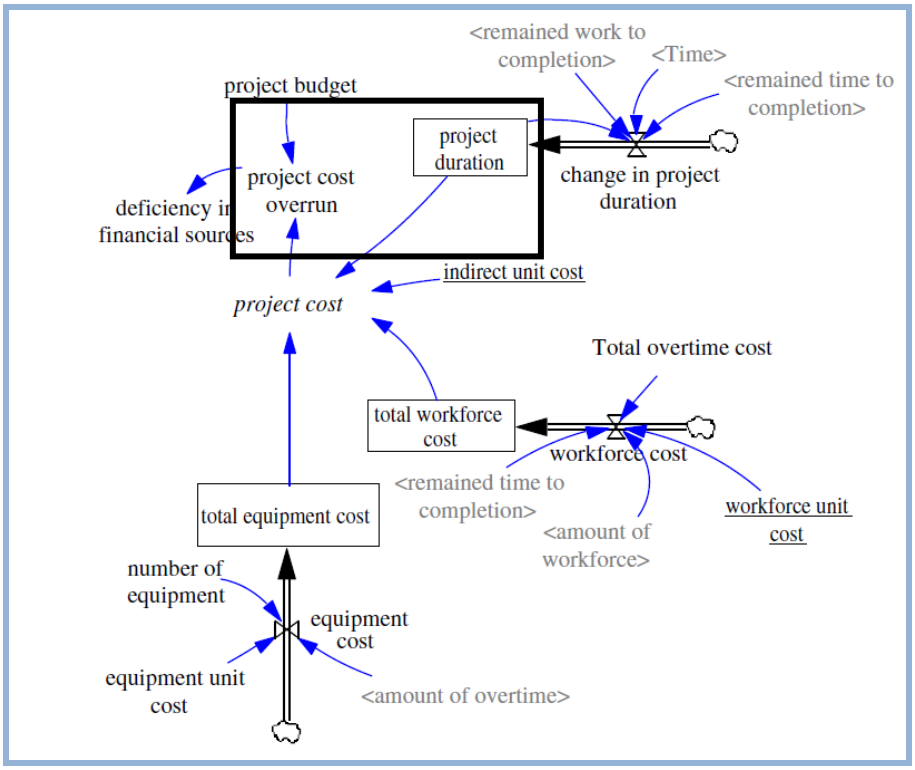


Figure 2-4. Project cost and duration sector (Nasirzadeh, 2013)

Above-mentioned studies focused on more macro level influence on labor productivity. Though both studies lack the

Though the purposes of previous studies are similar, which is to explain CLP with system thinking, the scope differs. Jang(2009) covered population, wage and construction workers. Nasirzadeh(2013) aimed particularly at government policies which cover wide scope from micro to macro ones.

The scope of this study distinguishes from previous studies. The focus lies on social influence mentioned earlier in Chapter 1. While this scope includes some parts of previous studies, it differs in meaning that the scale covers m ore wide scope of national status.

2.4. Summary

Historically, numbers of worldwide studies are performed to analyze the cause of productivity loss and the ways to improve it. Wen's study in 2014, show the leveling of these CLP studies by the scope of the study. Various micro scope approach has been proven in literature reviews showing personal effect to construction workers. However, because of the ambiguity and variability of macro scope influence (Wen, 2014), macro scope studies of CLP are insufficient and often incomplete.

This chapter introduce the influential factors in general CLP studies which shows the lack of macro scope approach. System Dynamics methodology is introduced to explain the basic principal and purpose of this methodology. Last part consists of SD approach CLP studies with its models and points to refer in this study. Besides, by recognizing the scopes of previous studies, it provides logicality to the scope of the study.

Chapter 3. Model Development

This chapter contains the procedure of building a qualitative System Dynamics Model explaining CLP index shown in Chapter 1. In order to sort the types of CLP, workers' individual productivity is designated as WCLP (Workers' Construction Labor Productivity), and Industrial CLP index as ICLP (Industrial Construction Labor Productivity).

Modeling initiated with the question of which properties of society has effect on construction industry. First step of modeling is to make base loops concerning CLP. By integrating the sub models and adding social influences, the modeling process is complete. Since the modeling is limited to qualitative level, the process mainly contribute to make logical and clear relations among the variables.

3.1. Modeling Goal

As mentioned earlier in Chapter 1, CLP index evaluate the utility of construction industry for the national economy. In this context, explaining the root cause of CLP fluctuation and the complex phenomenon concerning CLP might be a start to reach optimum Productivity in Construction Industry.

However, this CLP can be embraced as a complex social phenomenon (assuming that social influence determines CLP), which corresponds to the System dynamics modeling goal. System dynamics (SD) is an approach to understanding the nonlinear behavior of complex systems over time using stocks, flows, internal feedback loops, table functions and time delays.

3.2. SD Modeling Process

Following order shows the modeling process (Figure 3-1). Since the known main influential factor to CLP are number of workers and amount of work (or vitality of construction projects), main framework of model concern such variables.

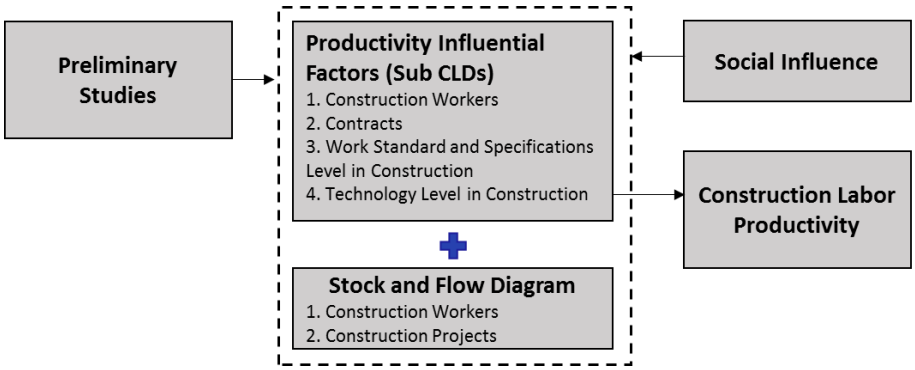


Figure 3-1. Modeling Process

3.3. Construction Labor Productivity Definition

Productivity as mentioned in Chapter 1, is basically used to evaluate the efficiency of the work. The various scopes of input variables add scope of the efficiency. Limiting the input values to micro level focusing on a single worker assigns the productivity to mean the efficiency of the average work of laborers. While, with more macro input values, productivity can stand for the efficiency of construction industry itself, otherwise referred to as "Profitability".

Labor productivity defined in this study covers total labor input of the nation's construction business and industrial outcome at economic focus. The following mentions of CLP therefore means industrial construction labor productivity.

Since the systematic approach(SD modeling) needs clear relation between each variables, CLP needs to be defined with precise causal relations. It appears that CLP and Profit of construction industry are related from Chapter 1. Formula below shows the definition of general Productivity.

$$Productivity = \frac{Output}{Input}$$

This might occur that the system of those variables can be perceived as <Output → Productivity>. However, concerning causal relation in reality, 'output' should be the final variable through the work process, concluding

that <Productivity →Output> is the right path. Therefore, in the modeling procedure, CLP is defined as follows. (Figure 3-2)

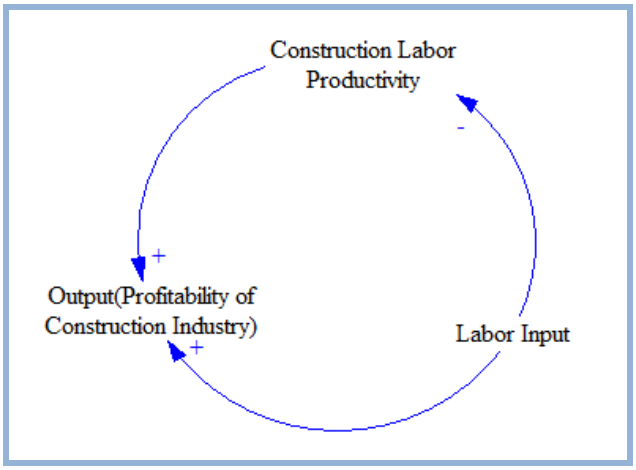


Figure 3-2. Definition of Construction Labor Productivity in SD Model

3.4. Social Influence Factors

The procedure of this sections purpose to compose a group of influential factors before building system dynamics model. The dictionary definition of social influence factor is “factors composing social environment.” It mentions that these factors vary from political system, economical status, population and structure, technological level to life style and education level. Variables derived from this definition is limited particularly to those can be qualified. Ambiguous factors such as life style are ignored in the process.

By adopting the dictionary definition and applying previous studies, before and during the modeling process secondary variables are sorted by the categories as follows (Table 3-1). From the category, the ideas to sub-models are gathered. Social influences are normally subordinative and complex. In order to make the model persuasive and clear, social factors are normally considered as exogenous variables in the model.

Table 3-1. Social Influence Factors on Labor Productivity

Social Factors Category	Secondary Variables
Population / Population Structure	Birth Rate Death Rate Working Population Retire Rate
Economy Status	GDP Wage Real Estate Economy Construction Contracts Industrial Economics
Technology Level	Construction Technology Level R&D Level
Education Level	Education Level Cognition of Construction Workers
Government Policy	Level of Construction Standards & Specifications Wage Policy Labor Policy

3.5. Detailed Causal Loop Diagrams

1) Population and Construction Workers

Microscope Studies resulted in the fact that Overtime Workhour is a main cause of Productivity Drop (Sink, 1985). It shows that this can be extended to macro level.

- Reinforcing loop 1: Worker → Productivity → Profitability → Order → Required Workers → Wage → Worker
- Reinforcing loop 2: Profitability → Order of Construction Projects
- Balancing loop 1: Projects → Workload → Productivity

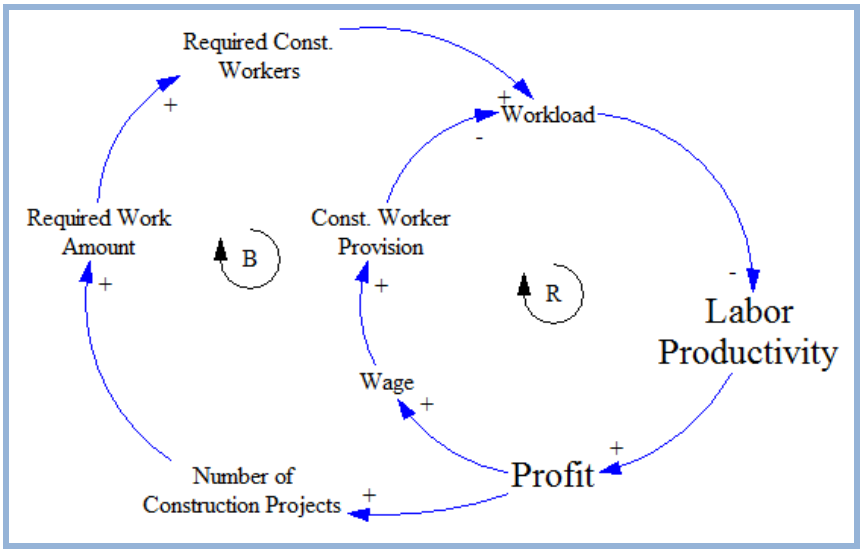


Figure 3-3. Construction Worker and Project loop

2) Work Standard and Specifications

Work Standard and Specifications in Construction industry can have effect on Productivity. Whereas, low standard level can cause safety issues, problems at construction site or to the quality of work.

- Balancing loop 2: Regulation Level → Problems, Work Quality → Reinforcement
- Balancing loop 3: Regulation Level → Labor Productivity (Due to High Consideration)

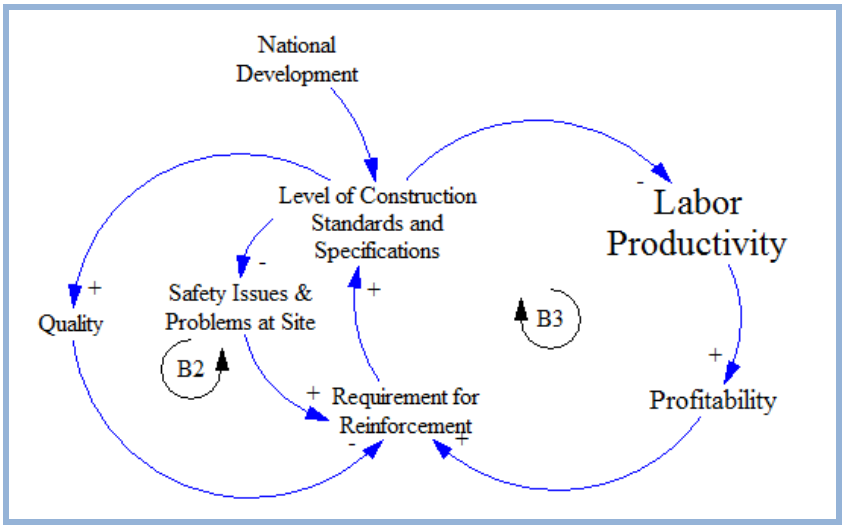


Figure 3-4. Standards and Specification Loop

3) Technology Level

National Development includes Technological Advancement. As in every industries, Technological Development is normally known to bring up labor productivity. The process of Technology advancement is shown as follows (Figure 3-4).

Balancing loop 4: Technology → Productivity → R&D

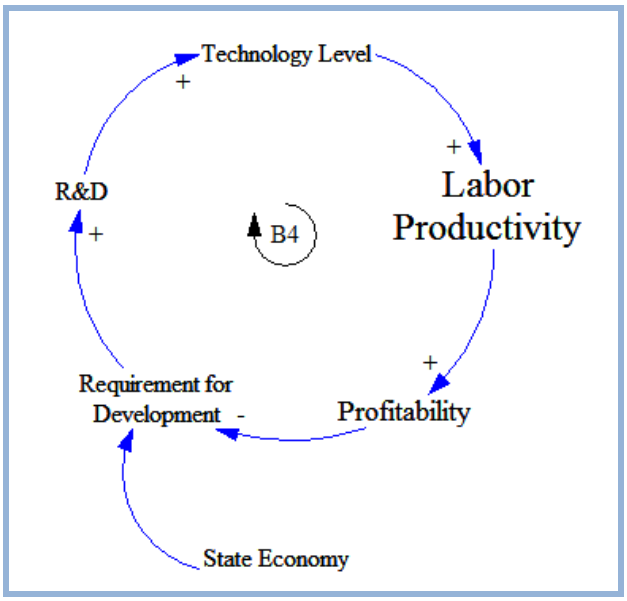


Figure 3-5. Technology Level Loop

4) Stock and Flow Diagrams

Construction Workers and Ongoing Construction Projects are adopted in forms of Stock and Flow as follows (Figure 3-5). It is to arrange the important values in clear shape to help understanding the complex model. Furthermore, this can help further quantification issues.

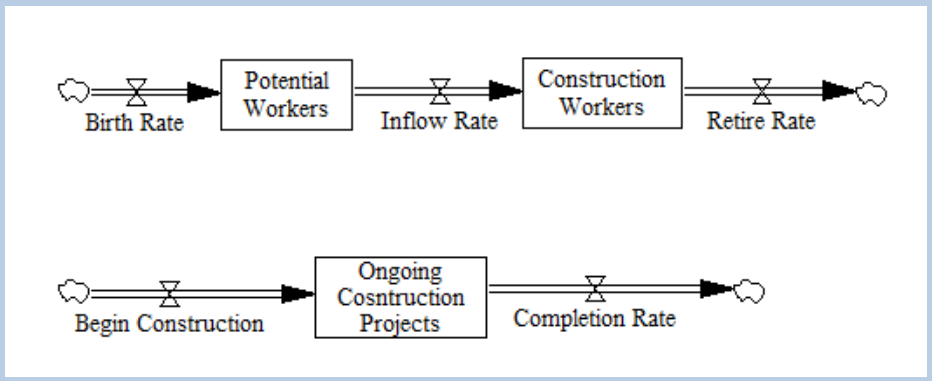


Figure 3-6. Stock and Flow concerning Construction Workers and Ongoing Construction Projects

3.6. Model Integration

Influence factors do not operate independently. (Nasirzadeh, 2013) Thus, model integration is important particularly that the variables used in each sub-models have their own relations. Based on previous CLDs and S&Fs, an integrated model of CLP is built as follows (Figure 3-6). Furthermore, exogenous social influential factors mentioned in Chapter 3.4 are added to the model.

During the process, a relation analyses of variables are shown as follows (Table 3-1) with grounds of the logic if necessary. Logics are adopted from previous studies and general social decisions.

Table 3-2. Relation analysis of Variables

Variable	Polarity	Variable	Grounds
WCLP	→(+)	ICLP	Expansion
	→(+)	Completion Rate	
ICLP	→(+)	Profit in Construction Industry	Index definition
Completion Rate	→(+)	Profit in Construction Industry	
Profit in Construction Industry	→(+)	Construction Contracts	Social decision
	→(-)	Requirement for CLP Improvement	
National Development	→(+)	Education Level	
	→(+)	GDP	
	→(+)	Level of Construction Standards & Specifications	
	→(+)	Construction Technology Level	
Level of Construction Standards & Specifications	→(-)	WCLP	High requirement

Relative Wage	→(+)		Depressed motivation
Workload per Worker	→(-)		Previous study
Construction Technology Level	→(+)		
Construction Workers	→(+)	Worker Sufficiency	
Worker Sufficiency	→(-)	Relative Wage	
	→(-)	Workload per Worker	
Ongoing Construction Projects	→(+)	Required number of Workers	
Real Estate Economy	→(+)	Predicted Real Estate Economy in the Future	
Education Level	→(-)	Inflow Rate	Job selection process
Cognition of Construction Workers	→(-)		

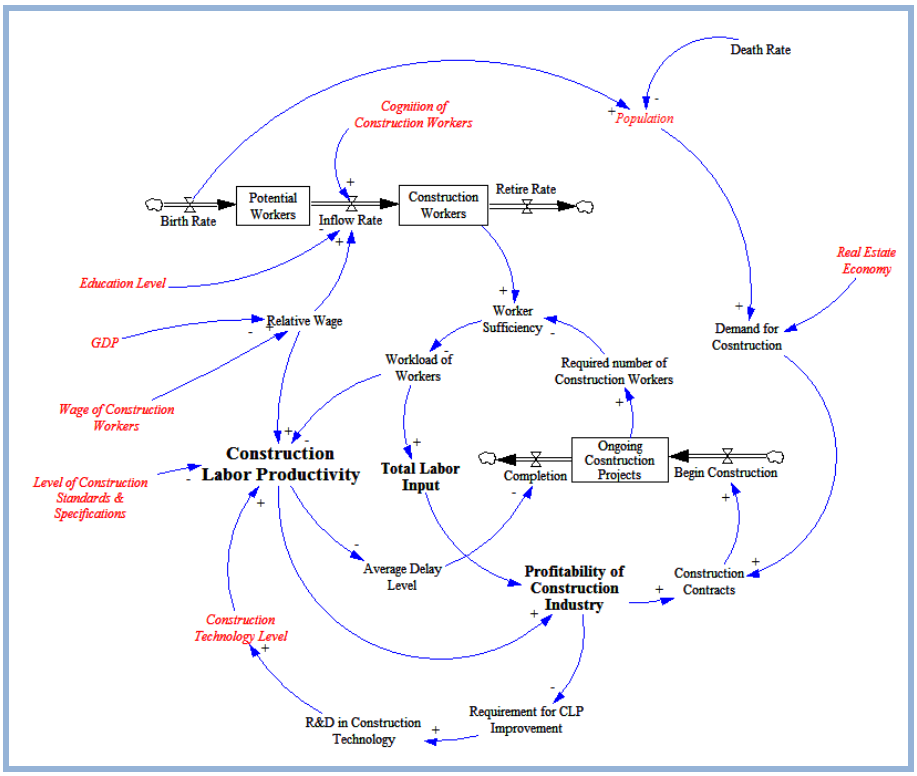


Figure 3-7. Integrated CLP Model

3.7. Summary

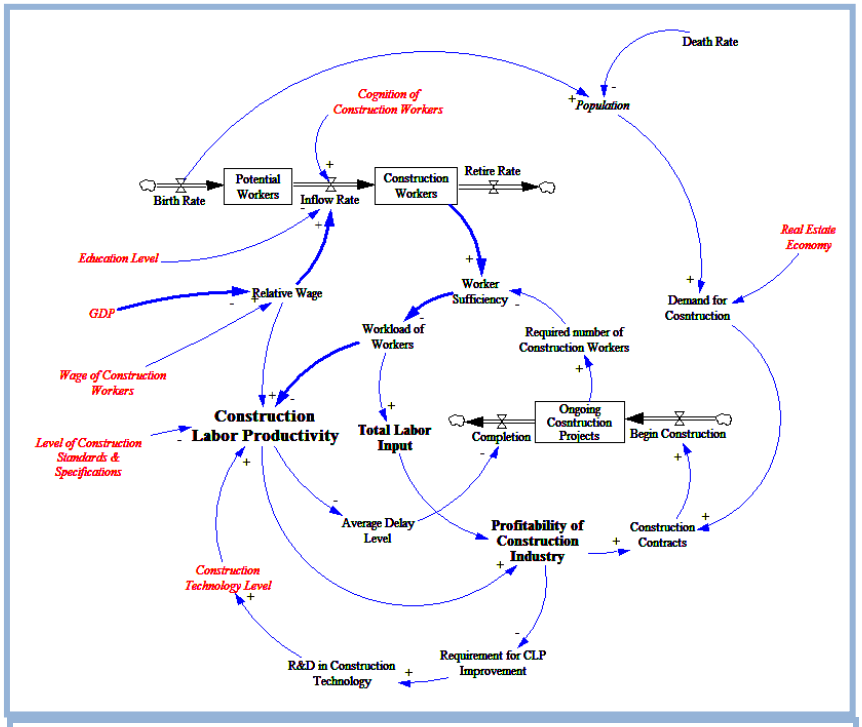
The purpose of building a System Dynamics modeling is to explain CLP condition along with social influences. Model consists of Stock and Flow diagram concerning construction workers and construction projects and CLDs. CLDs are built in four specific subjects concerning workers, projects, work standards and technology level. Model integration is performed, and Causal loops connect S&F diagram with CLP and social status factors are included in various logics.

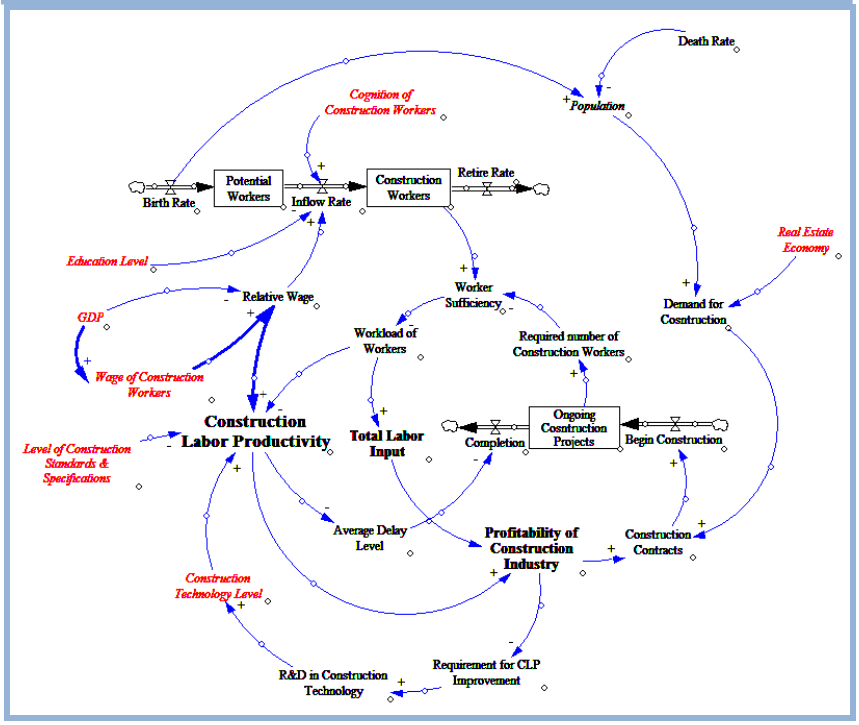
Chapter 4. Results

4.1. Model Analysis

CLP index shows the utility of construction industry in national economy. SD model in this study shows the effect of national status to CLP. SD model enables to verify the social influences to CLP.

For example, national development increases GDP result in low relative wage that decreases CLP. This means a rapid change in such variable brings about a huge fluctuation of CLP. In this chapter, the influential paths of social factors are analyzed as the form of trade-offs shown in figure 4-1. Figure shows three influential paths concerning GDP. Upper two paths shows negative effect on CLP while bottom one shows a positive effect. This trade-offs and leverage of each variables and its influential maps are describes as follows. (Table 4-1) Appendix A. covers more details of influential paths.


Death Rate
Population
Cognition of Construction Workers
Potential Workers
Construction Workers
Retire Rate
Birth Rate
Inflow Rate
Education Level
Real Estate Economy
Relative Wage
Worker Sufficiency
Demand for Cosntruction
GDP
Workload of Workers
Required number of Construction Workers
Wage of Construction Workers
Construction Labor Productivity
Total Labor Input
Ongoing Cosntruction Projects
Completion
Begin Construction
Level of Construction Standards & Specifications
Average Delay Level
Profitability of Construction Industry
Construction Contracts
Construction Technology Level
Requirement for CLP Improvement
R&D in Construction Technology


Death Rate
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Workload of Workers
Required number of Construction Workers
Wage of Construction Workers
Construction Labor Productivity
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Average Delay Level
Profitability of Construction Industry
Construction Contracts
Construction Technology Level
Requirement for CLP Improvement
R&D in Construction Technology

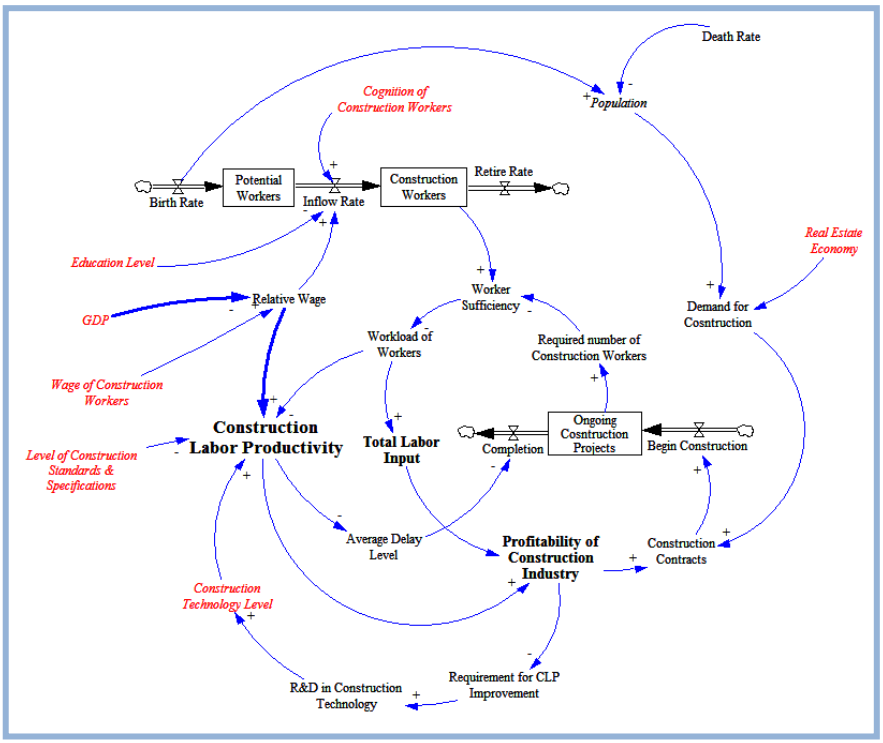

Figure 4-1. Influential Paths and Trade-Offs of GDP Influence

Table 4-1. Analysis of Social Influence on CLP

Social Factors	Influential map	Leverage
GDP	→(-)Relative wage→(+) Inflow →(+) Workers →(+) Productivity	(-)
	→(-)Relative wage →(+) Inflow →(+) Workers →(+) Labor Input →(+) Profit	(-)
	→(+)Wage →(+) Productivity	(+)
Education Level	→(-) Inflow →(+) Workers →(+) Productivity	(-)
Technology Level	→(+) Productivity	(+)
Birth Rate	→(+)population →(+)Projects →(-)Sufficiency →(-)Productivity	(-)
	→(+)Workers →(+)Productivity	(+)
Cognition of Construction worker	→(+) Inflow →(+) Workers →(+) Productivity	(+)

4.2. Implications

The model has limitations for remaining at qualitative level. Though the trade-offs of social influences are shown at perceived level, there can be some implications can be figured.

It is often believed that national development brings about the growth of productivity. However, it is found that the representative factor of national development, GDP shows unknown effect on CLP. Furthermore, it could occur that since more developed society has more chance and wider range of fluctuation to social factors, which means higher chance to fluctuation of productivity. It also appears that along with single variable having its own trade-offs in the model, national development itself also can have meaning as a sort of trade-off.

Model also shows some feedback loops including CLP. There shows two balancing loops and one reinforcing loop. This implies that CLP, as predicted, has complex movement through the change of social influence factors.

Chapter 5. Conclusions

5.1. Discussion

CLP index shows the utility of construction industry in national economy. SD model in this study shows the effect of national status to CLP. SD model enables to verify the social influences to CLP.

For example, national development increases GDP result in low relative wage that decreases CLP. This means a rapid change in such variable brings about a huge fluctuation of CLP.

Analysis of this model gives only limitative clue of the social influence on CLP. However, this could be valuable in predicting the unknown future CLP with reasons.

5.2. Contribution

SD model built in this paper has differentiation to previous works in that the focus of modeling is the social influence. This discrimination makes this model to be able to face CLP at macro level.

This study started from the question of which properties of society has effect on construction industry. Though it remains to be a qualitative model, this model can help explain the trends of CLP index.

Additionally, with proper data of national status, the prediction of CLP in near future could be possible. This can be a meaningful evidential material for decision makers in construction contractual process.

5.3. Further Study

This study resulted in explaining CLP through a qualitative modeling. The ambiguity of macro level variables and difficulty of quantifying such variables makes it difficult to quantify the model. However, modeling process reveals a possibility of quantification at some level. Quantification of the model adds more validity to the result and quantification and proper national status data will enable the simulation of future CLP progress.

This study simplified the variables and relations in this model for to avoid complexity and make clear logic. In further study, a concrete model allocated in specific subject can add more logic to the models.

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Homepage of Korean productivity center.

(*http://www.kpc.or.kr/Productivity/index.asp/*)

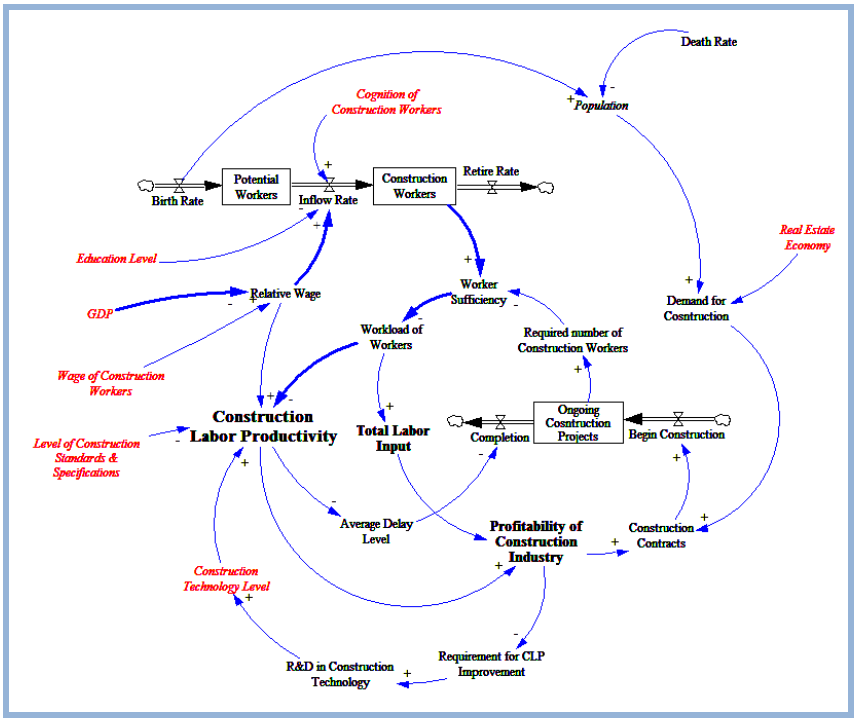
Homepage of Korean Statistical Information Service

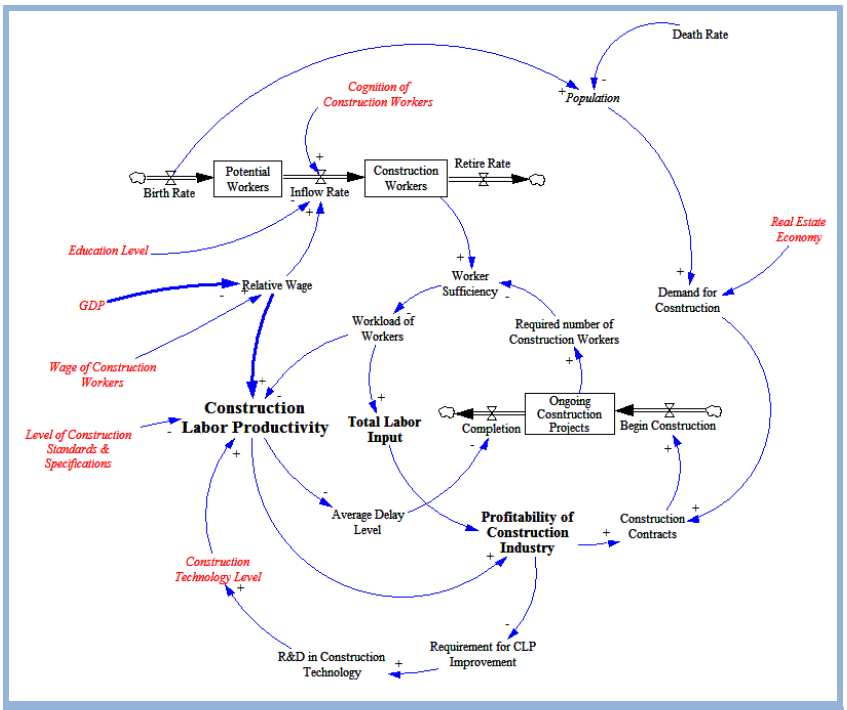
(*http://kosis.kr/statisticsList/*)

Appendix

A. Influential Paths and Tade-Offs of GDP Influence

A.1. Analysis of GDP on CLP




Death Rate
Population
Cognition of Construction Workers
Birth Rate
Potential Workers
Inflow Rate
Construction Workers
Retire Rate
Education Level
Real Estate Economy
Relative Wage
GDP
Worker Sufficiency
Demand for Cosntruction
Workload of Workers
Required number of Construction Workers
Wage of Construction Workers
Construction Labor Productivity
Total Labor Input
Ongoing Cosntruction Projects
Completion
Begin Construction
Level of Construction Standards & Specifications
Average Delay Level
Profitability of Construction Industry
Construction Contracts
Construction Technology Level
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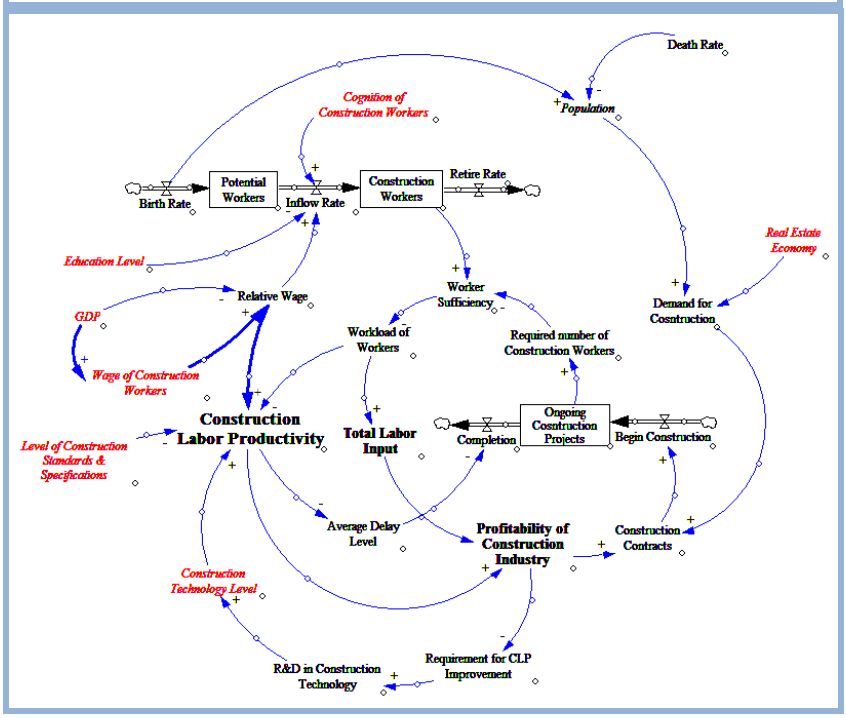
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Completion
Begin Construction
Level of Construction Standards & Specifications
Average Delay Level
Profitability of Construction Industry
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Construction Technology Level
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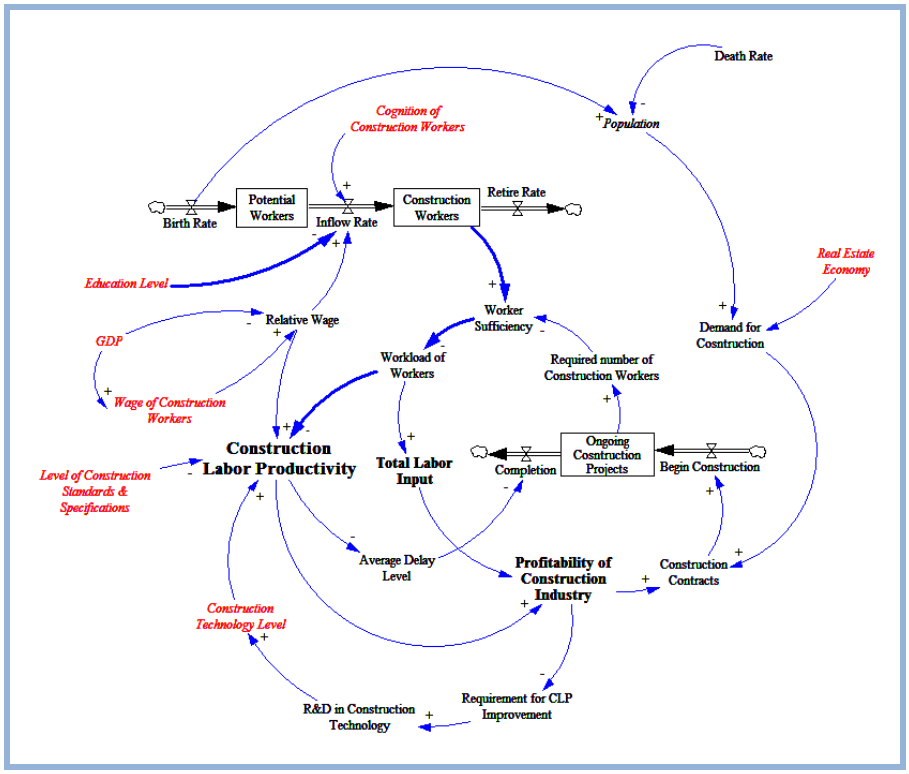
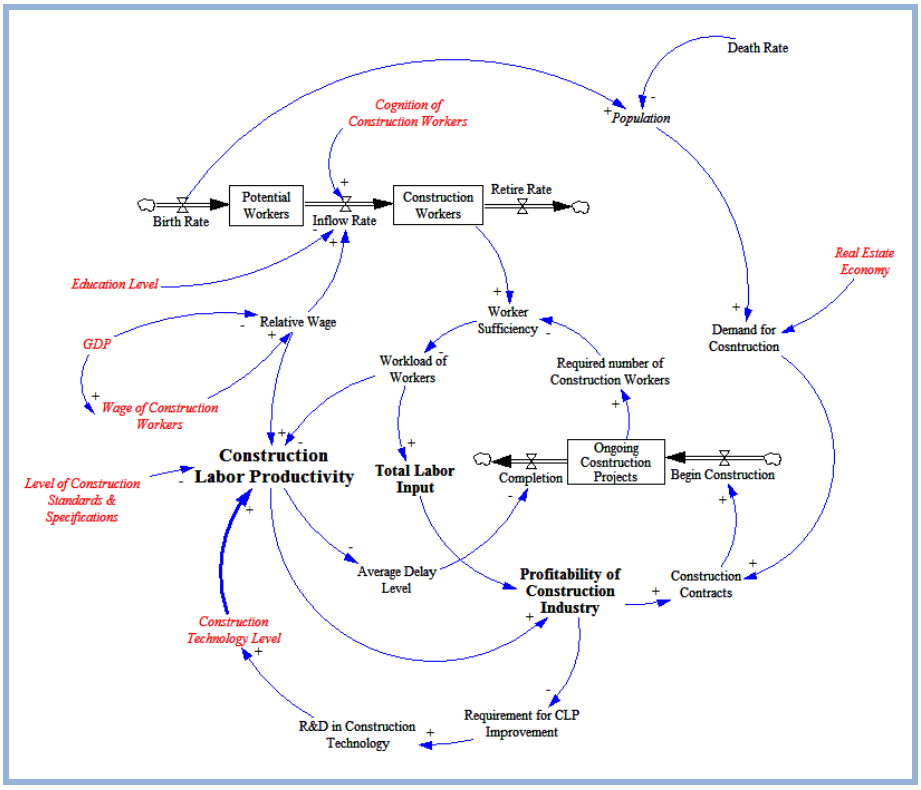
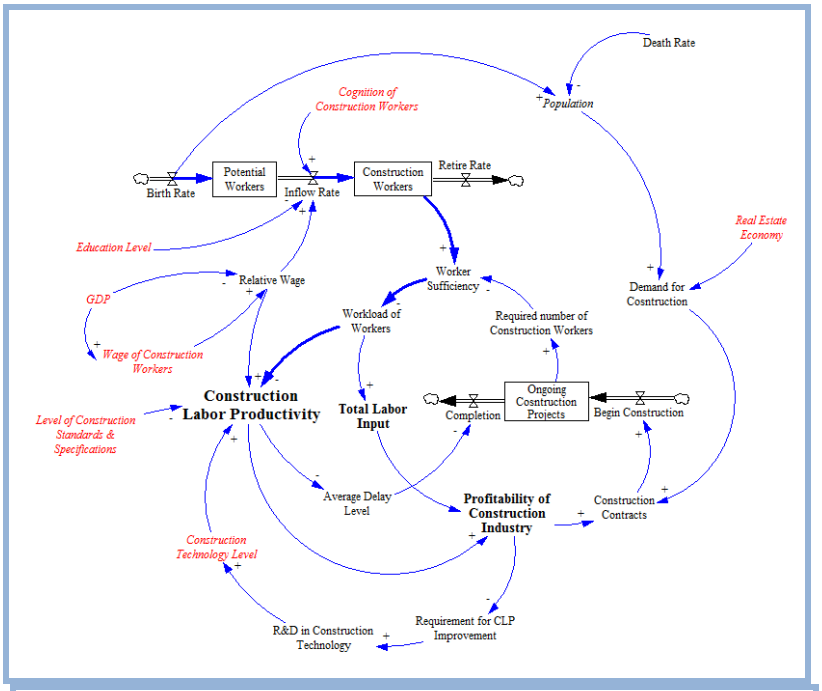
A.2. Analysis of Education Level on CLP

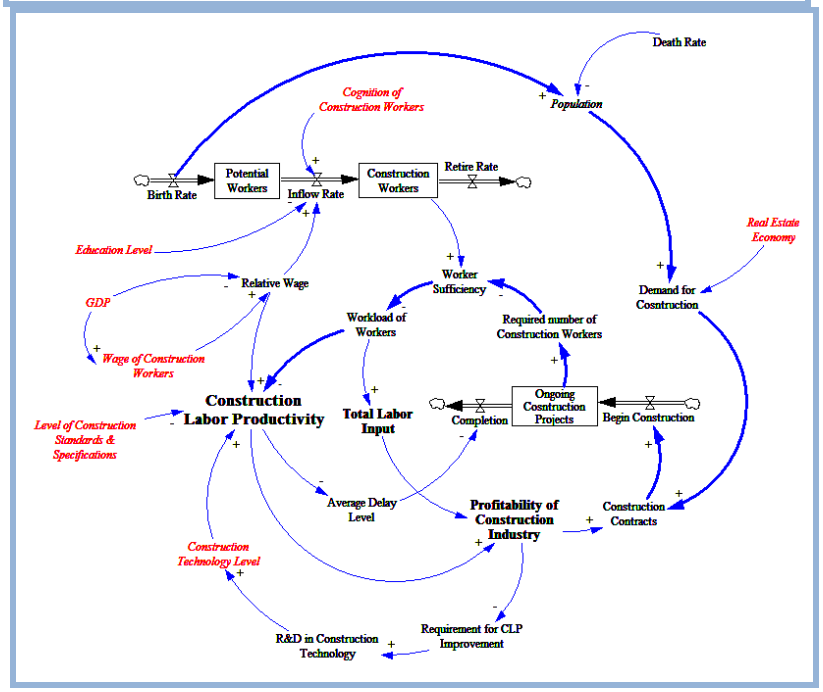


A.3. Analysis of Technology Level on CLP

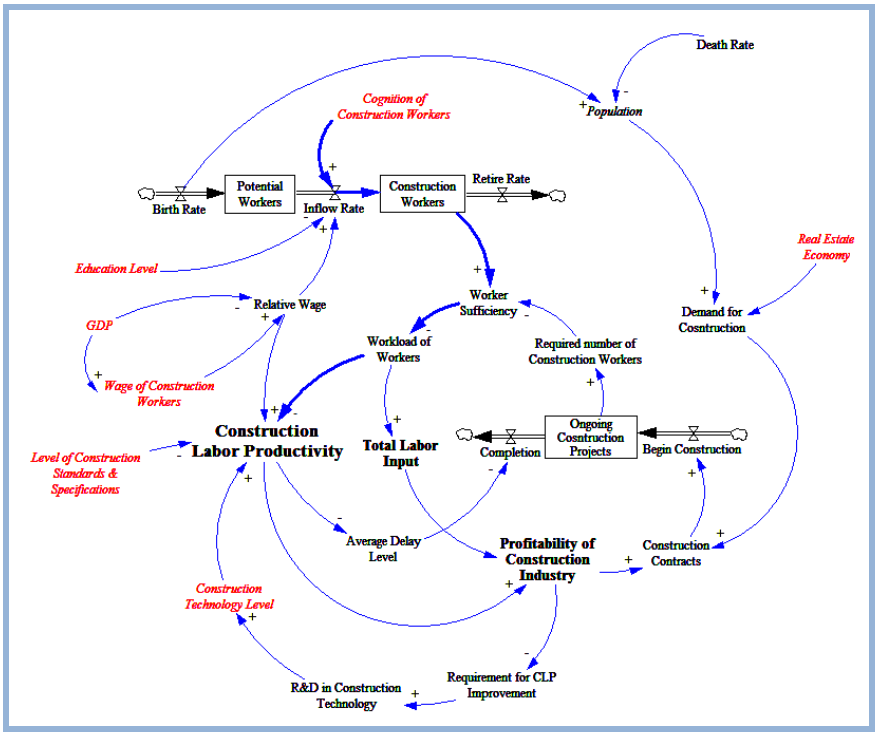


A.4. Analysis of Birth Rate on CLP





A.5. Analysis of Cognition of Construction Workers on CLP



국 문 초 록

생산성은 특정 산업의 산업경쟁력과 직결되는 중요한 지표이다. 건설업은 노동 집약적 산업으로 노동 생산성의 중요성은 더욱 높다고 할 수 있다. 한국 건설업의 기술 수준은 세계적으로 높지만 생산성의 수치는 매우 낮은 것으로 밝혀졌다. 또한 연간 생산성의 데이터를 통해 생산성의 변동폭이 매우 높다는 점 또한 평균 생산성을 낮추는 데 영향을 주고 있다. 국내뿐만 아니라 전 세계적으로도 낮은 노동 생산성은 건설업에서 중요한 문제로 대두되어 왔다.

이러한 생산성의 중요성에 따라 건설업에서 노동 생산성을 설명하고 향상시키기 위한 다양한 연구가 전 세계적으로 진행되어 왔다. 생산성 연구의 중요한 부분은 그 영향요인에 대한 분석과 관련된다. 생산성에 영향을 미치는 요인을 밝히고, 그 영향 관계를 파악하는 것이 생산성 연구에서 큰 비중을 차지하는 것이다. 이 영향요인에 대해서는 그 범위에 따라 작업 수준부터 국가적 차원까지 범주가 다양하다. 노동 생산성의 주체가 작업자이기 때문에 역사적으로 작업자 수준의 영향요인에 대한 연구가 활발히 진행된 바 있다. 이는 미시적 관점에서의 생산성을 설명하기 적절한

방법이라 할 수 있으나 생산성 지표라는 거시적인 현상을 설명하기에는 범위가 좁다.

본 연구에서는 건설 노동 생산성을 하나의 사회 현상으로 받아들이고, 사회적 요인이 생산성에 미치는 영향을 분석하려 한다. 이에 생산성을 사회적 맥락에서 설명하는 시스템 다이내믹스 모델을 작성한다. 정성적 시스템 다이내믹스 모델을 통해 다양한 사회적 요인이 건설 노동 생산성에 미치는 영향을 분석하였으며, 이는 사회적 변동에 의한 건설업 노동 생산성의 반응을 예측하는 데 도움을 줄 수 있다.

키워드: 건설 노동 생산성, 생산성 저하, 생산성 변동, 사회적 영향, 거시적 관점, 시스템 다이내믹스

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