Case analysis on indirect economic benefits of industrial building construction

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Abstract. In this paper, the economic benefits of prefabricated buildings which are not directly reflected in the economic returns of investors are called indirect economic benefits. Based on the literature mining of the indirect economic relationship of a large number of prefabricated buildings, this paper constructs an analysis framework of indirect environment and social and economic benefits. Through BIM modeling software, the three prefabricated building models are modified into traditional building models. The indirect economic benefits of the project are calculated by using the index system. The functional relationship between the indirect economic benefits of prefabricated buildings and the assembly rate is established by using the SSPS statistical data processing software, which more intuitively shows the law of the indirect economic benefits of prefabricated buildings with the assembly rate It shows the impact of prefabricated building on environment and society, which is of great significance for the harmony between prefabricated building and society and environment, and the healthy and sustainable development of construction industry.

1 Construction and modification of indirect economic benefit model

The theory is as shown in figure below.

Name	Carbon dioxide emission reduction
Calculation rules	$E_{CO2} = P \times Q_{CO2} \times 10^{-3} \times J_{CO2} \times 10^{-3}$
Symbolic meaning	E_{CO2}:CO2 emission reduction value (10000 yuan) P: building area (m^2) Q_{CO2}: prefabricated building reduces carbon emissions by kg / m2 per square meter compared with traditional buildings J_{CO2}:reference unit price of current carbon trading market yuan / ton
Name	Human health indicators
Calculation rules	$E_{human\ health} = P \times Q_{CO2} \times H \times 10^{-4}$
Symbolic meaning	$E_{human\ health}$: economic benefits brought about by reducing health damage (10000 yuan) P: building area m^2 Q_{CO2}: prefabricated buildings reduce carbon emissions by kg/m^2 per square meter compared with traditional buildings, H:1kg CO_2 emissions, social willingness to pay - WTP (yuan / kg)

Fig. 1. Brief introduction of environmental benefit theory.

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Name	Increase of labor productivity(IOLP)
Calculation rules	$E_{IOLP} = \sum_{i=1}^{i=n} (\eta_{2i} - \eta_{1i}) \times Q_i \times 10^{-4}$
Symbolic meaning	η_{1i}: the average labor productivity of the construction industry in the first year is (yuan / person) η_{2i}: the average labor productivity in the first year of construction industrialization is (yuan / person) n ：construction period (year) Q_i: number of construction workers e labor productivity: E_{iolp}: indirect social and economic benefits brought by labor productivity improvement (10000 yuan)
Name	Ease labor shortage(ELS)
Calculation rules	$M_i = F_i \times S \qquad E_{ELS} = \sum_{i=1}^{n} (X_i - Y_i) \times M_i \times 10^{-4}$
Symbolic meaning	F_i: financial labor wage of the I-year construction project (yuan) S: Shadow Wage conversion coefficient M_i: Shadow Wage of employees in the I-year construction project (yuan) X_i: number of people required by traditional construction mode Y_i: number of people required for prefabricated building construction mode in the I-year E_{ELS} ：indirect economic benefits brought about by labor shortage (10000 yuan)
Name	Construction safety improvement(CSI)
Calculation rules	$E_{CSI} = \sum_{i=1}^{n} [(T \times Qi) - (N \times Pi)] \times Y \times S \times M$
Symbolic meaning	T：Number of people required for traditional construction N：number of people required by prefabricated building construction mode Y： number of years that the accident person can continue to work M： average annual wage of Beijing construction industry (10000 yuan) S: Shadow Wage conversion coefficient Q_i: annual accident mortality rate of traditional construction mode in China in the I year P_i: annual accident mortality rate of prefabricated building mode in the I year E_{CSI} ：indirect economic benefits brought by improvement of construction safety performance (10000 yuan)

Fig. 2. Indirect social benefit theory.

2 Case model analysis

2.1 Economic benefits of emission reduction

Table 1. Calculation of economic benefits of emission reduction.

	Steel consumption difference(kg)	Wood consumption difference(m^3)	Concrete consumption difference(m^3)	Carbon saving($kgCO_2/eq$)	CO2 emission reduction value (yuan)
1#	13768.0	550.7	106.2	288320.8	8649.6
2#	12662.2	508.2	97.1	249931.4	7498.0
3#	13099.2	524.0	101.1	274348.3	8230.4

2.2 Human health indicators

Table 2. Case calculation of economic benefits of physical health.

	Carbon saving($kgCO_2/eq$)	WTP(yuan/kg)	Economic benefits of Health (10000 yuan)
1#	288320.8	6.74×10^{-6}	1.943×10^{-4}
2#	249931.4	6.74×10^{-6}	1.684×10^{-4}
3#	274348.3	6.74×10^{-6}	1.849×10^{-4}

2.3 Increase of Labor Productivity (IOLP)

Under the premise of considering the impact of project progress efficiency on labor turnover, the labor productivity of current housing industrialization can increase by 52%

Table 3. Calculation of economic benefits of labor productivity.

	Construction personnel (person)	Construction period (year)	Economic benefits of labor productivity (10000 yuan)
1#	719	3	24028.9
2#	702	3	23275.5
3#	751	3	25596.5

2.4 Ease Labor Shortage (ELS)

The construction period of the three projects in this paper is from 2018 to 2021, and the employment wages of the national construction industry are 63428 yuan, 69879 yuan and 74890 yuan respectively.

Table 4. Calculation of economic benefits of relieving the pressure of labor shortage.

	Number of construction workers in traditional construction mode (person)	Number of construction workers in prefabricated construction mode (person)	Shadow Wage conversion coefficient	Economic benefits of relieving the pressure of labor shortage (10000 yuan)
1#	1700	719	0.65	13275.5
2#	1700	702	0.65	13505.8
3#	1800	751	0.65	14195.8

2.5 Improvement of construction safety performance

The annual accident mortality rate of prefabricated building mode in China is 30% - 50% lower than that of traditional building mode in China. the median value of 40% is taken in the calculation process. Assuming that the accident person can continue to work for 30 years, and the Shadow Wage conversion coefficient can be taken as 0.65.

Table 5. Calculation of economic benefits of construction safety performance improvement.

	Number of construction workers in traditional construction mode (person)	Number of construction workers in prefabricated construction mode (person)	Shadow Wage conversion coefficient	Construction safety performance and economic benefits (10000 yuan)
1#	1700	719	0.65	140.5
2#	1700	702	0.65	189.2
3#	1800	751	0.65	202.1

3 Comprehensive analysis of case data

Table 6. Indirect economic benefits of the project and its corresponding assembly rate.

name	Assembly rate	Indirect economic benefits
1#	50%	3.74bn
2#	40%	3.69bn
3#	60%	3.99bn

3.1 Curve regression equation

The regression equation obtained from the regression analysis of Figure 1 is:y= 0.001x2-0.085x+5.490

variable	Coefficient of non standardization		Standardization coefficient		
	B	SE B	Beta	t	Sig
Assembly rate (%) (z)	-0.085	0	-5.288	-	-
Assembly rate (%) (z2)	0.001	0	6.232	-	-
constant	5.49	0		-	-

Fig.3. Regression analysis.

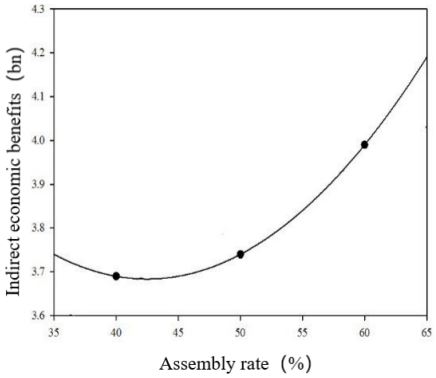

Fig. 4. Quadratic fitting curve.

4 Conclusion

With the increase of assembly rate, the indirect economic benefit is increasing rapidly. And the research on the curve shows that the indirect economic benefit of prefabricated building is the lowest when the assembly rate is 42.5%. This is because the traditional buildings provide a lot of employment opportunities, and make the construction period longer, so that the indirect social benefits are greater.

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