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Research on the Relationship Among Technical Standards, Economic Growth, and Innovation

An Empirical Study of Chinese Construction Industry Data

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***Abstract*—As a pillar industry of the country, the construction industry is very important to the development of the country. This paper firstly analyzes the relationship among technical standards, economic growth and innovation, and then combines Chinese construction industry data, based on VAR model, using Stata.14 software for data analysis to study the dynamic relationship among construction industry technical standards, economic growth and innovation. The results show that standards and economic development can better explain innovation; economic growth and building standards are positively related to innovation; the impact of standards on innovation is greater than that of economic growth, with standard changes of 1% and innovations of 1.27. %, while a 1% change in the economy can bring about a 0.6% change in innovation. The paper will present some thoughts on how to push construction industry in developing countries in which there suffers insufficient capital to code with the issues.**

Keywords: technical standards, economic growth, innovation, construction industry

I. Introduction

Construction is a vital part of the “One Belt and One Road” construction. In order to better play the role of the leader in the “One Belt and One Road”, China cannot do without the development of the construction industry. As the “One Belt and One Road” initiative is an infrastructure-led integration program, as part of its infrastructure investment activities, China's foreign direct investment in infrastructure areas along the “One Belt and One Road” initiative is expected to increase [1]. China's building standards, construction industry economic growth and architectural innovation can all play a role in the construction of the “One Belt and One Road”. Open standards can generate powerful innovation effects that help stimulate economic development [2]. Technical standards have at least the same impact on economic growth as patents, and patents often represent innovation [3]. An important function of the standards is the production risk of fewer manufacturers and the risk of user use [4]. In addition, standards enable companies to use specialization and continuous productivity to gain economic benefits and enhance market competitiveness [5]. Therefore, having the right to formulate product standards means that having a competitive advantage in products. Standards are often used by some countries to address technological backwardness in innovation and backwardness to promote economic development [6]. For the study of the relationship among technical standards, economic growth and innovation, scholars tend to focus on the overall level of the country, while there is less research on the industry level. This paper focuses on the relationship among China's construction industry technology standards, technological innovation and economic growth, and selects China's construction industry data for empirical analysis, in order to provide support for the better development of the “One Belt and One Road”.

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II. Literature Review

A. Technical standards and innovation

As a code of conduct, standards play a certain role in regulating or regulating innovation activities. Technical standards affect the speed and direction of technological innovation with its unique norm [7] [8]. There are two different conclusions from existing scholars on the impact of standards on innovation. (1) Positive promotion. An important role of standardization is to synchronize disjointed technological innovations into system innovations to create a new market [9]. The emergence of this new market often marks the emergence of a series of innovations. Companies with dominant standards are more competitive and the resulting increase in market concentration is enough to compensate for the increase in innovation costs [10]. Thus, standards are good for innovation and diversify product innovation [11]. At the same time, standards as technical specifications are also conducive to the spread and spread of innovation [12]. To a certain extent, this encourages companies or countries to innovate in pursuit of interests, and to maintain standards of innovation at the top of the industry. (2) Negative hindrance. In the process of its implementation, standards will hinder innovation due to its inherent technology lock-in effect [13]. The standard owner is satisfied with the existing results in order to protect its benefice. In addition, because of the standards limit the creativity of workers to a certain extent and reduce their chances of exercising these abilities, it is not conducive to the improvement of innovation ability [14]. In low uncertain markets, standards limit corporate innovation efficiency more, however, in highly uncertain markets, the opposite is true [15]. Therefore, standards can also be a hindrance to innovation.

B. Technological innovation and economic growth

Technological innovation is considered to be a crucial factor driving economic growth [16]. There is a one-way and two-way causal relationship in economic growth. These results vary from different country and depend on the type of innovation used in the empirical investigation [17]. Technological innovations include the introduction or creation of new products, services, new processes and new methods. Technological innovation can not only produce a certain level of output with less input, but also shift from non-renewable energy to renewable energy to maintain economic development [18]. Innovation makes companies more competitive, but at the same time, innovation is complex and expensive, and innovators sometimes need to collaborate and share information. If the ability of innovators to share and cooperate is higher, the innovation output and economic output is higher [19] [20]. The contribution of technological innovation to economic performance is particularly evident at the corporate and industry levels, and whether the economy can grow in the long run usually depends on the growth rate of its technological innovation [21]. For products with short technology distances, technological innovations lead to the emergence of common technologies, thus ensuring sustained economic growth [22].

C. Technical standards and economic benefits

The conclusions about the relationship between technical standards and economic benefits are mainly divided into two aspects. On the one hand, Technical standards enable product technology to spread and reduce the risk of entering the market by eliminating obsolete products, thereby improving the economic efficiency of the enterprise and the growth of the industry economy [23]. At the same time, technical standards can increase the profitability of producers and consumers, promote price competition among enterprises, and generate economies of scale on the demand side [24]. On the other hand, technical standards affect technological innovation, technology diffusion, and industrial structure, and determine the profitability of companies in the industry. However, the existence of multiple standards in the industry may limit economies of scale and network effects, thus inhibiting overall market economic growth [25]. The regularization and standardization of technology will reduce the market competitiveness of professional and technical personnel, and form an environment that is not conducive to a virtuous circle of innovation. In the long run, it will become a resistance to economic growth [26].

D. Technical standards, innovation and economic growth

Technical standards, economic growth and innovation are not separated from each other and they are mutually infiltrated and influential. Among them, innovation can provide enterprises with new technologies and through the sales of new products and join-in a new markets to gain economic benefits, thus driving economic growth; Socio-economic growth has increased the demand for new products and promoted technological innovation. Similarly, technical standards begin with technological innovation. In order to obtain greater economic benefits and occupy a more favorable market, enterprises will inevitably raise technology to standards; the formation of technical standards and the better diffusion of innovative technologies, thereby increasing the impact of technological innovation. In addition, technical standards contribute to the improvement of the total efficiency of enterprises and society through its network effect, and promote faster economic growth; Socio-economic growth has made the requirements for standards more and more high, and can promote the formation of technical standards. The relationship among technical standards, innovation and economic growth is shown in Figure 1.

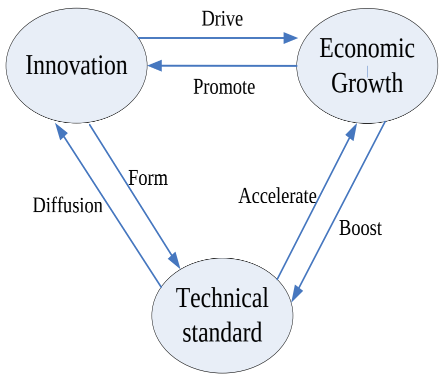

Fig. 1. Relationship among technical standards, innovation and economic growth

III. THE MODEL AND DATA

The model selected in this paper is a vector autoregressive (VAR) model, which empirically analyzes the relationship between China's construction industry technical standards, economic development and construction industry innovation. Vector autoregressive (VAR) is based on the statistical properties of data. The VAR model constructs a model by using an endogenous variable in the system as a function of the hysteresis of all endogenous variables in the system, thereby extending the univariate autoregressive model to multiple time A "vector" autoregressive model consisting of sequence variables. The VAR model is one of the easiest to operate algorithms for analyzing and predicting multiple related economic indicators. Under certain conditions, multivariate MA and ARMA models can also be transformed into VAR models. Therefore, in recent years, VAR models have received more and more attention from economic workers. The metrics and data sources for variables are shown in Table 1.

TABLE I. VARIABLE METRICS AND DATA SOURCES

Variable	Metrics	Data Sources
Construction industry standard	It is measured by the industry standards and national standards of China's construction industry. The number of specific standards is the annual published standard quantity stock minus the annual abolished standard quantity.	Standard statistical yearbook of China
Construction industry economic development	Based on the total output value of China's construction industry	National Bureau of Statistics of China
Construction industry innovation	Taking the number of patent applications in China's construction industry as a measure	National Bureau of Statistics of China

In order to eliminate the time series heteroscedasticity and linearize its trend, the natural logarithmic transformation is carried out on the basis of the existing data, and the total construction value of China's construction industry and engineering construction are represented by $\ln gdcp$, and $\ln std$ and $\ln pat$ respective standard stock and construction industry patent applications. The data is shown in Table 2. Among them, $GDCP$ has been converted into a constant price based on 1995.

TABLE II. CHINA'S CONSTRUCTION INDUSTRY GDCP, PATENT FILINGS AND TECHNICAL STANDARDS STOCKS FROM 1995 TO 2016

YEAR	GDCP	STD	PAT	LnGDCP	LnSTD	LnPAT
1995	3733.7	684	19705	8.225155	6.527958	9.888628
1996	4056.325	770	20341	8.308033	6.646391	9.920394
1997	4502.237	837	21387	8.41233	6.729824	9.970539
1998	5033.266	922	20734	8.523824	6.826545	9.93953
1999	5254.462	993	25153	8.566833	6.900731	10.13273
2000	5511.952	1075	30836	8.614674	6.980076	10.33644
2001	5904.171	1149	39702	8.683414	7.046647	10.58916
2002	6534.375	1244	44403	8.784832	7.126087	10.70106
2003	7421.739	1310	47439	8.912169	7.177782	10.7672
2004	8393.167	1401	56229	9.035173	7.244942	10.93719
2005	10216.6	1493	63691	9.231769	7.308543	11.0618
2006	12266.11	1618	84647	9.414595	7.388946	11.34624
2007	14645.04	1789	95316	9.591857	7.489412	11.46495
2008	17759.77	1930	128042	9.784691	7.565275	11.76011
2009	22841.39	2111	142684	10.03633	7.654917	11.86839
2010	26388.48	2385	194842	10.18068	7.776954	12.17994
2011	31239.56	2621	277362	10.34944	7.871311	12.53308
2012	35961.11	2903	425250	10.49019	7.9735	12.96043
2013	39860.43	3236	480392	10.59314	8.082093	13.08236
2014	44000.49	3625	477265	10.69196	8.19561	13.07583
2015	45982.94	3908	693443	10.73603	8.270781	13.44942
2016	48728.33	4140	800090	10.79402	8.328451	13.59248

IV. EMPIRICAL ANALYSIS

A. Sample description

The sample is firstly described using Stata.14 software. The descriptive statistical characteristics of the data are shown in Figure 2.

```
. su lngdcp lnstd lnpat

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
      lngdcp |         22    9.452779    .8988645   8.225155   10.79402
       lnstd |         22    7.414217    .5486467   6.527958   8.328451
       lnpat |         22    11.43445    1.245276   9.888628   13.59248
```

Fig. 2. Sample description statistics

According to Figure 2, the difference between the maximum value and the minimum value of $\ln gdcp$ and $\ln std$ is small, and the difference between the minimum value and the maximum value of $\ln pat$ is large, which indicates that the innovation has a large gap in each year. The time trend of *pat* and $GDCP$ is shown in Figure 3.

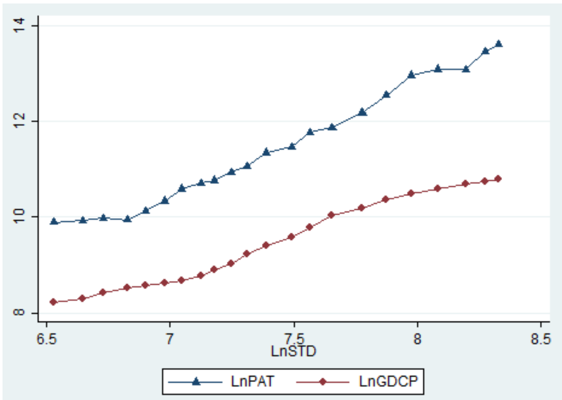

Fig. 3. Time trend of pat and $GDCP$

According to Figure 3, the patent is positively related to *GDCP*. Consider the following regression model, as in (1).

$$lnpat_t = \beta_0 + \beta_1 lngdcp_t + \beta_2 lnstd_t + \varepsilon_t \quad (1)$$

B. Regression analysis

OLS regression is performed on $\ln pat$, $\ln gdcp$, and $\ln std$, and the results are shown in Figure 4.

```
. reg lnpat lngdcp lnstd

      Source |       SS           df       MS      Number of obs   =        22
-------------+----------------------------------   F(2, 19)        =    730.16
       Model |  32.1466934         2  16.0733467   Prob > F        =    0.0000
    Residual |  .418255922        19  .02201347    R-squared       =    0.9872
-------------+----------------------------------   Adj R-squared   =    0.9858
       Total |  32.5649493        21  1.55071187   Root MSE        =    .14837

------------------------------------------------------------------------------
       lnpat |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lngdcp |   .6038827   .2547214     2.37   0.028     .0707447    1.137021
       lnstd |   1.271338   .4173178     3.05   0.007     .3978821    2.144794
       _cons |  -3.699897   .7884654    -4.69   0.000    -5.350174    -2.04962
------------------------------------------------------------------------------
```

Fig. 4. The results of OLS regression

According to Figure 4, the results of OLS regression show that $\ln pat$ and $\ln gdcp$ are significantly not equal to 0 at the 2.8% level. Since this is time series data, the disturbance term may have autocorrelation, so the residual $e1$ and its hysteresis value $e2$ are calculated, and the residual and residual hysteresis values are fitted. The result is shown in Figure 5. According to the results of Figure 5, the disturbance term may have a positive autocorrelation. The autocorrelation and partial autocorrelation are shown in Figure 6 and Figure 7.

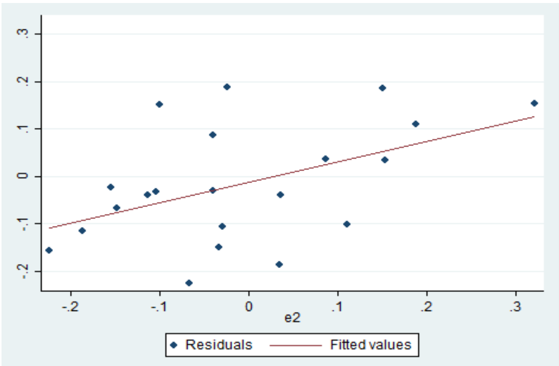

Fig. 5. Scatter plot of residual and residual lag

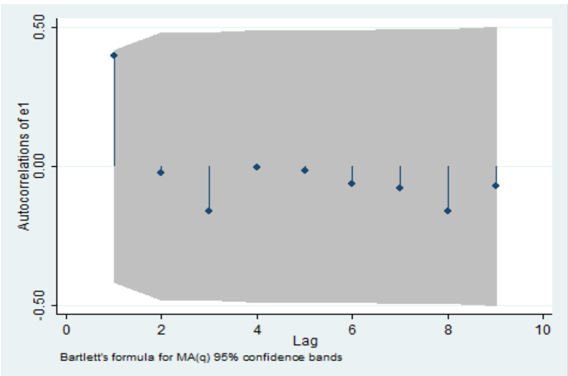

Fig. 6. Autocorrelation chart

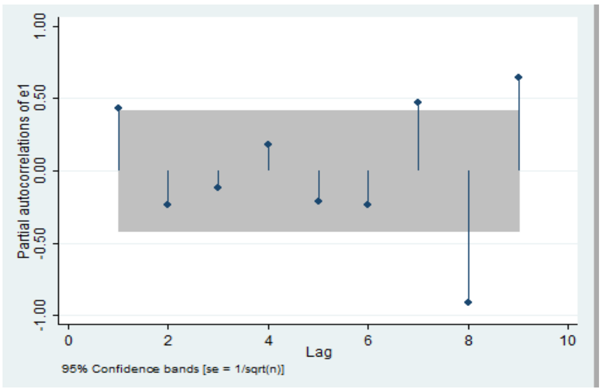

Fig. 7. Partial correlation graph

The two graphs show that the form of autocorrelation is mainly first-order and high-order can be roughly ignored.

C. BG test

The BG test is performed below, and the results are shown in Figure 8. The p-value of the BG test is 0.0484, which means that the "no autocorrelation" hypothesis can be rejected at a significant level of 5%, and there is an autocorrelation.

```
. estat bgo

Breusch-Godfrey LM test for autocorrelation
---------------------------------------------------------------------------
    lags(p)  |          chi2               df                 Prob > chi2
-------------+-------------------------------------------------------------
       1     |          3.897               1                   0.0484
---------------------------------------------------------------------------
                        H0: no serial correlation
```

Fig. 8. The results of BG test

V. CONCLUSION

As an indispensable part of the “Belt and Road” infrastructure project, construction engineering plays an important role in promoting overall economic development and enhancing national influence. Especially for China, it is both the initiator and the practitioner of the “Belt and Road”. The development of its engineering construction directly affects trade and cooperation with other countries. This paper mainly analyzes the relationship among construction standards, construction industry economic growth and innovation through China's existing construction industry data. The conclusions as below:

1) Model innovation is better than using innovation as an explanatory variable rather than using standards and economic development as explanatory variables. This shows that standards and economic development can better explain the results of innovation. Although economic development and innovation can also explain standards, the regression effect does not regard innovation as an explanatory variable, and economic development as an explanatory variable is also not optimal. The relationship between construction industry standards, economic growth and innovation is mutually influential, but it is best to use innovation as an explanatory variable. Standards and economic growth are the most powerful weapons for competing for more industry or inter-state voices, and technological innovation is often

required before standards are established. Therefore, the economic growth brought about by the proliferation of standards encourages technological innovation in enterprises or countries.

2) Economic growth and innovation are positively related. The faster the economy development, the more innovation it brings. In construction industry, if a country's economic level is higher, then the innovation ability is stronger. In the implementation of the "One Belt and One Road", China has brought economic growth to neighboring countries and promoted the innovation and development of those countries. Similarly, to have stronger innovation capabilities requires stronger economic support. Only when the economy develops well will there be more capital invested in more innovative development. Countries with strong economic strength can afford the excessive costs brought about by development and innovation. Because of that in the early stage of innovation, a large amount of capital investment is often required, and these inputs sometimes cannot be expected to produce innovative results. There are often times when inputs exceed innovation output.

3) Building standards are positively related to innovation. Standards influence innovation with its unique network effects. In the construction industry, the establishment of building standards means the determination of a certain norm, and a regulated enterprise or country can gain more voice and competitive advantage in the construction industry. Therefore, the innovation brought by building standards is usually the embodiment of competition. The competition for standards is ultimately the embodiment of innovation ability. Countries with international standards tend to have strong ability of innovation, and the greater their voice in the international market, the more capable they can innovate.

4) The impact of building standards on innovation is greater than the impact of economic development on innovation. Standards change by 1%, innovations change by 1.27%, and economic changes of 1% can lead to 0.6% innovation changes. Innovation brought about by standard proliferation is more than innovation brought about by economic growth alone. Standards are not only a manifestation of economic development, but also have a unique aspect to the impact of innovation. Having a standard usually means that innovation and economic development reach a certain level, and national standards and industry standards also represent the level of development of the country and industry. In the "One Belt and One Road" initiative, the owners of technical standards generally have a positive attitude towards the diffusion of their standards. Once this standard is widely used, its economic benefits are much higher than simply developing the economy. Therefore, we should actively innovate and promote innovation as a new standard.

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