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Measuring Work Autonomy and Its Role in Enhancing Labour Productivity: The Case of the Vietnamese Construction Industry

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Abstract: Work autonomy (WA) is an important factor in improving work performance, yet such freedom and its role in construction workforce management have rarely been discussed. To address this gap, this study quantitatively measured the WA of onsite construction workers in Vietnam, developed a new model by which to discover the function of WA in increasing construction labour productivity (CLP) and determined the ways through which WA can be cultivated and maintained. The WA of 215 workers was measured using the relative autonomy index (RAI) and an aggregated motivation index (AMI) that was developed in this research. Structural equation modelling (SEM) was conducted to examine the effects of WA on CLP. The SEM results indicated that WA positively and significantly contributed to CLP. Promoting WA required paying attention to the competence and relatedness satisfaction of the workers. Furthermore, latent and potentially extensive labour management-related problems were identified, namely, unsuccessful career development and the underutilisation of experienced workers. Three meaningful policy recommendations were put forward to solve the aforementioned problems and improve CLP: the effective organisation of crew members, the improvement of training and the improvement of site amenities. This study expands theoretical knowledge by (1) developing and justifying the AMI as an auxiliary to conventional indices, (2) proposing five conditions necessary for optimal scoring in WA measurement and (3) developing a motivation matrix that identifies and distinguishes the attributes of different groups. In practical terms, the findings support the introduction of reasonable policies that advance the career development of workers, promote WA and improve CLP. These achievements, in turn, significantly advance effective and sustainable construction workforce management.

Keywords: work autonomy; basic psychological needs satisfaction; RAI; AMI; CLP

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1. Introduction

Autonomy at work favourably influences an individual's work performance [1,2], creativity [3] and well-being [4]. Work autonomy (WA) is neither about passively enabling employees to be independent nor allowing work in isolation or work without guidance, boundaries, supervision or collaboration. Such freedom revolves around clearing the way for employees to work in a manner that is most conducive to excellent performance. Promoting autonomy at work means empowering employees to exercise self-control, granting them stewardship over their work and environment and providing them with support instead of exerting control over them [5]. Autonomy at work can also help employees feel valued and accountable for the tasks that they oversee, and when they feel trusted, they are likely to perform exceptional work. Therefore, increasing autonomy in the workplace generates win–win outcomes that benefit both employers and employees [6].

Despite significant technological advancements, construction remains a labour-intensive industry [7]. Thus, the enhancement of construction labour productivity (CLP) can markedly advance project effectiveness [8] and generate substantial cost savings for

construction organisations [9]. Onsite, a worker is part of a construction crew and executes many tasks that range from very easy to difficult and require physical labour. Some of these activities are dangerous and hazardous. Therefore, improving CLP in a sound manner necessitates understanding how many onsite workers experience WA, why some workers experience such freedom while others do not, what kind of WA they enjoy, how it influences CLP and what measures should be taken. Notwithstanding the importance of such issues, however, limited studies have been devoted to WA in the construction industry.

The first steps in exploring WA among onsite construction workers are determining how their WA levels can be measured and implementing this measurement. One such method for quantitatively assessing autonomy at work is a powerful general indicator called the relative autonomy index (RAI), which has been continually developed [10–12]. Its adjusted modifications have become the most widely used measure of autonomy in behavioural research [10–12]. The RAI is a suitable tool for measuring WA among onsite workers, including those working in the context of Vietnam, where construction managers believe that empowerment is key to enhanced work performance and some are willing to grant increased authority to workers provided that they generate desirable outcomes [13,14]. Nevertheless, because WA in the construction industry has been minimally investigated, this concept may not be sufficiently understood or shared by many construction practitioners. This case gives rise to the possibility that indices other than the RAI are more appropriate for characterising WA among onsite construction workers and explaining its contribution to CLP. This assertion is supported by the fact that although WA has been found important in enhancing work performance [1,2], a study in the construction domain found both the autonomous and controlled motivation of onsite Vietnamese workers as positive and significant contributors to CLP enhancement [15]. Accordingly, the second step in exploring WA among onsite workers is to examine the influence of this freedom on CLP.

The third step in the above-mentioned exploration is to identify how WA can be cultivated. The ways by which WA can be fostered and maintained can be explained on the basis of self-determination theory (SDT), specifically through the satisfaction of three basic psychological needs: autonomy, competence and relatedness. SDT also clarifies the degree to which the motivation to engage in activities is deemed internal (i.e., the degree of self-involvement) and how varying levels of this self-determination influence the selection of actions that generate desired outcomes [16].

The fourth step is to identify and discuss policy implications on the basis of the results acquired in the previous three steps. In this research, we focused on the WA and CLP associated with simple tasks that do not require outstanding skills. Most onsite workers begin their practice implementing straightforward responsibilities, such as rebar and masonry tasks, which account for the majority of construction quantity and cost for multi-storey residential projects in Vietnam. By focusing on these tasks, we could characterise each group of workers on the basis of certain attributes, such as length of experience and gender. A clear characterisation of each worker group shed light on the advantages and disadvantages of current labour management and policy in Vietnam.

The last step in exploring the WA of onsite construction workers is to ascertain what the optimality of WA scoring protocols means—an issue that has yet to be resolved [17]. We argue that optimality should be considered on the grounds of each step discussed above, that is, taking into account the effectiveness of index-driven characterisation, its contribution to CLP improvement, a clear identification of influencing factors for WA and the persuasiveness of policy recommendations.

To sum up, to improve CLP, we sought to enhance existing knowledge of WA in the construction industry by pursuing the following objectives:

- To determine how the WA of onsite construction workers can be ascertained and to quantitatively measure this construct;
- To analyse the contribution of WA to CLP improvement;

- To identify how WA can be cultivated and maintained through the satisfaction of the three basic psychological needs;
- To derive and discuss policy recommendations for improving CLP;
- To cast light on the meaning of optimality in WA scoring protocols.

2. Theoretical Framework and Hypotheses Development

2.1. Self-Determination Theory

SDT assumes motivation to be the primary driver of people's actions or behavioural performance, implying that individuals enjoy conquering their social environments and are naturally self-motivated to do so [16,18]. The theory proposes that all motivated behaviours can be located on an underlying autonomy continuum [19,20], lying somewhere between feeling a complete lack of self-determination (external motivation) and experiencing thorough self-determination (internal motivation) [16]. Along this continuum, low to high levels of self-determination are determined on the basis of six constructs: amotivation, external regulation, introjected regulation, identified regulation, integrated regulation and intrinsic regulation. Amotivation refers to situations wherein individuals perceive no contingencies between outcomes and their actions, driving them to grapple with feelings of incompetence and uncontrollability [21]. External regulation represents behaviours that are managed through external means, such as reward or punishment. Introjected regulation pertains to behaviours that are beginning to be internalised, but are not fully self-determined. These behaviours can be performed, for example, to gain social recognition or avoid internal pressures and feelings of guilt [19]. Identified regulation refers to relatively self-determined behaviours that occur when individuals place value on and judge an activity as important to the self [20]. Integrated regulation is reflected in the attainment of inherently valued and important goals or outcomes, but such an action is fully endorsed by individuals [22]. Intrinsic regulation means highly autonomous behaviours that stimulate feelings of fun, pleasure and satisfaction, which stem from participation in an activity [19,23]. If these constructs are to be classified in terms of motivation, then external regulation and introjected regulation are types of controlled motivation (which reflects low autonomy), whereas identified regulation, integrated regulation and intrinsic regulation belong to autonomous motivation (which points to high autonomy). These subscales of the self-determination continuum are used as bases for quantitatively determining the RAI and accordingly uncovering the level of autonomy exercised by an individual in a given activity or task.

2.2. The Relationship between Work Autonomy and Construction Labour Productivity

Previous studies emphasised the important role of WA in enhancing work performance [1,2,5] and demonstrated a consistent and positive relationship between these variables. For instance, researchers asserted that high autonomy improves employees' work performance because under such conditions, they perceive themselves as capably and resourcefully performing a task [24]. Other scholars described individuals with high autonomy as feeling responsibility for their work outcomes given that their personal initiative-related judgment of how to carry out tasks can directly influence such outcomes [25]. These insights are considered applicable to the construction sector despite the absence of quantitative studies on the relationship between WA and work performance in this industry. Some construction practitioners have emphasised the significant role of autonomy at work in labour productivity improvement [13,14]. More specifically, autonomous motivation (which, in SDT, refers to high autonomy) significantly and positively contributes to worker productivity [15]. In line with these arguments, therefore, we examined the relationship between WA and CLP on the grounds of the following supposition:

Hypothesis 1 (H1). *WA is associated with onsite worker productivity (represented by CLP).*

2.3. The Relationship between the Satisfaction of Three Basic Psychological Needs and Work Autonomy

A necessary task is to explore the ways by which WA can be cultivated and maintained, and this objective can be accomplished by adopting a suitable motivational theory. In this regard, basic psychological need theory, one of the six constituent perspectives under SDT [16,26,27], is a promising lens through which to elaborate on how psychological satisfaction can promote individuals' autonomy to engage in an activity or task. Basic psychological need theory describes human beings as having three basic psychological needs, namely, autonomy satisfaction, competence satisfaction and relatedness satisfaction [19,26]. The need for autonomy is satisfied when one experiences a sense of volition, psychological freedom and authorship in one's thinking, acting and feeling [16,28]. SDT's notion of autonomy also encompasses the absence of pressure and conflict [29,30]. The need to feel competent is satisfied when a sense of mastery and efficacy in one's activities is perceived. One feels that one is capable of what one does and is able to accomplish projects and achieve one's goals [16,31]. Finally, the need for relatedness is satisfied when people experience a sense of communion and develop close and intimate relationships with others [16]. Relatedness pertains to the intrinsic yearning of individuals to feel connected to others, that is, to be a member of a group, to love and care and to be loved and cared for [32].

In the SDT framework, the satisfaction of basic psychological needs (i.e., autonomy, competence and relatedness) is assumed to represent the underlying motivational mechanism that energises and directs people's behaviours [16]. Such satisfaction is regarded as the essential component in individuals' optimal functioning and well-being, similar to how water, minerals and sunshine are critical for plants to bloom [16,22]. SDT postulates the existence of psychological satisfaction as important in individual motivation, growth and performance [19,26]. The relationships between basic psychological need satisfaction (BPNS) and work motivation are consistent [22], and WA can be measured on the basis of different types of motivation falling within the self-determination continuum. To date, however, no study has examined the link between the three basic psychological needs and WA.

We, therefore, confirmed whether such a relationship exists and accordingly hypothesised favourable relationships between the three basic psychological needs and the WA of onsite construction workers. To begin with, psychological satisfaction contributes to autonomy at work because, as demonstrated in [33,34], the satisfaction of autonomy, competence and relatedness needs facilitates intrinsic motivation, which corresponds to the highest autonomy in SDT. Researchers likewise discovered that both competence satisfaction and relatedness satisfaction significantly and positively contribute to autonomous motivation, which also points to a high level of autonomy in SDT [15]. When workers are empowered with authority, they are willing to participate at work because they feel an elevated sense of choice and freedom to do their designated tasks [13,14]. When they are satisfied with their competence, they tend to voluntarily engage in activities intended to help them prove themselves, especially challenging ones. When their need for relatedness is met through valuable interpersonal relationships with teammates, these connections generate positive emotions and increase cognitive processing. These effects naturally induce and foster proactive engagement with work, thereby preserving valuable ties, enhancing practical skills or encouraging the receipt of appreciative feedback from teammates. On the grounds of this discussion, we formulated the following hypotheses:

Hypothesis 2 (H2). *Autonomy satisfaction is associated with the WA of workers.*

Hypothesis 3 (H3). *Competence satisfaction is associated with the WA of workers.*

Hypothesis 4 (H4). *Relatedness satisfaction is associated with the WA of workers.*

The research model of this study is presented in Figure 1.

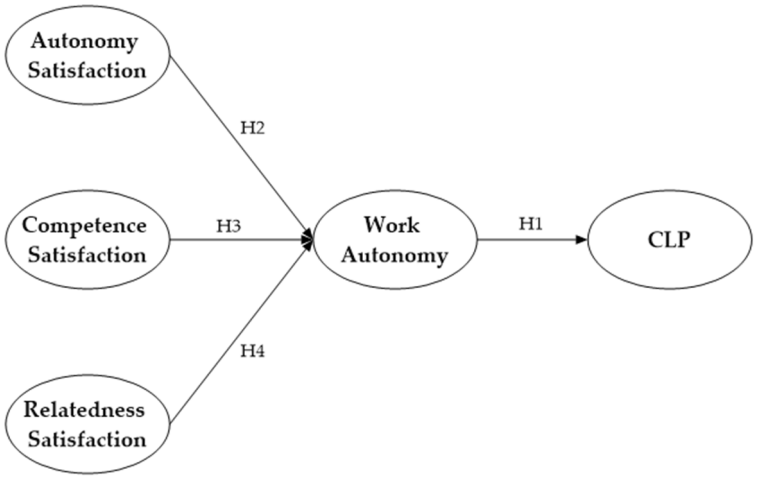

Figure 1. Research model.

3. Materials and Methods

3.1. Participants and Procedure

Participants were selected from a database of workers involved in five multi-storey residential projects in Vietnam. The interviewees were rebar and masonry workers with a comprehensive understanding of onsite tasks. To collect data, we developed a questionnaire consisting of two main parts. Part I revolved around the general demographic information of the participants. Part II comprised statements designed to measure the variables treated in this work using a five-point Likert scale. Before the questionnaire was distributed, we first carried out a pilot study with construction professionals and practitioners (i.e., 3 academic experts, 1 project manager, 4 supervisors, 2 foremen, and 11 workers). The pilot involved 21 participants, who were asked to evaluate and provide constructive feedback on the suitability of the language, the content validity of the questionnaire, its structure and sequencing of questions, and its completeness. After receiving their feedback and comments, we revised the questionnaire (e.g., enhancing readability, understandable, and refining CLP measurement scales). For the face-to-face interviews, we carefully trained four research assistants for them to comprehensively understand the research objectives, the content of the questionnaire and necessary survey techniques.

After the questionnaire was finalised, a survey was administered to 215 rebar and masonry workers in Vietnam from April to July 2021. On the sites where the respondents worked, their companies were constructing multi-storey residential buildings, for which almost similar structural design features and construction methods were used. Their participation was entirely voluntary, and they were informed of their right to withdraw at any time. They were assured of anonymity and that their privacy would be respected. The workers were briefed on the scope of the research before the questionnaires were administered, after which informed consent was obtained from them. The interview and questionnaire completion lasted approximately 40 min for each participant.

The participants were recruited via snowball sampling, which is a non-probability technique. Specifically, interviews were initiated with a small number of workers overseen by a single contractor. Then, the sample was expanded, with the initially chosen respondents asked for referrals from other contractors.

With the questionnaire as guidance, we interviewed 215 construction workers, among whom 122 were rebar workers (56.7%) and 93 were masonry workers (43.3%). The demographic information of the workers is shown in Table 1.

Table 1. Demographic characteristics of the respondents.

	Category	Frequency	Percentage
Gender	Male	187	87.0%
	Female	28	13.0%
Educational level	Primary school (1st–5th grades) and below	65	30.3%
	Secondary school (6th–9th grades)	94	43.7%
	High school (10th–12th grades) and above	56	26.0%
Age	≤35 years old (young workers [1])	162	75.4%
	>35 years old (older workers)	53	24.6%
Work experience	<5 years	94	43.7%
	5–10 years	84	39.1%
	>10 years	37	17.2%
Marital status	Single	50	23.3%
	Married	165	76.7%
Income [2]	Low income	95	44.2%
	High income	120	55.8%
Training	Untrained	182	84.7%
	Trained [3]	33	15.3%

[1] According to Youth Law No. 57/2020/QH14 (dated June 16, 2020), which was introduced by the Vietnamese National Assembly, young people are individuals aged 35 years and below [35]. [2] The yearly average income was calculated on the basis of Circular No. 15/2019/TT-BXD (dated 26 December 2019) of the Vietnamese Construction Ministry, which provides instruction on the calculation of unit labour costs in the construction sector [36]. Accordingly, the yearly average income is 3534 USD (1 USD = 22,952.5 VND). Workers in the low-income group have a yearly income less than 3534 USD (mean = 3356 USD), and workers in the high income group have a yearly income equal to or more than 3534 USD (mean = 4172 USD). [3] Workers who took part in a professional training are defined as trained workers, otherwise, as untrained workers.

In this study, we expect that there would be a significant difference in the levels of autonomy at work in some demographic factors. That is why some factors such as workers' marital status and income were included in the demographic characteristics of respondents, though they may not significantly affect their productivity.

3.2. Instruments

The variables of interest were measured using well-established scales from prior studies after they were carefully evaluated for suitability in the construction domain.

3.2.1. Six Motivational Subscales

Motivational subscale items were obtained from [37–39] and measured on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The question stem was 'Why do you or would you put effort into your current job on a construction site?' Amotivation was measured with four items (e.g., 'I don't because I really feel that I am wasting my time at work'), external regulation with nine items (e.g., 'Because I will be rewarded financially only if I put enough try into my job'), introjected regulation with six items (e.g., 'Because I have to prove to myself that I can'), identified regulation with six items (e.g., 'Because I receive appropriate feedback from my supervisors, teammates'), integrated regulation with five items (e.g., 'Because putting try into this job aligns with my personal values') and intrinsic regulation with eight items (e.g., 'Because I enjoy finding valuable solutions from others').

3.2.2. Three Basic Psychological Needs

We used the 17-item BPNS scale [40,41], which has three psychometrically sound structural components that distinctly measure autonomy satisfaction (five items; e.g., 'I feel a sense of choice in the tasks I undertaken'), competence satisfaction (six items; e.g., 'I feel effective in what I do onsite') and relatedness satisfaction (six items; e.g., 'I experience a

comfortable feeling with the people I spend time with onsite'). The items were rated using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

3.2.3. Construction Labour Productivity

Five simple tasks (or tasks that do not require excellent skills) in which the workers exhibited productivity onsite were determined and rated on a five-point scale ranging from 1 (the lowest productivity) to 5 (the highest productivity). The items were ascertained on the basis of regulation No.10/2019/TT-BXD of the Vietnamese Construction Ministry for the Promulgation of Construction Norms [42] and in-depth discussions with Vietnamese construction professionals. An example of statements directed to rebar workers is as follows: 'How many average kilograms of rebar can you process per shift (eight hours)?' The evaluation scales were <150, 150 to 170, 171 to 190, 191 to 210 and >210 kg. An example of questions presented to masonry workers is 'How many average cubic metres of straight walls can you build using baked clay bricks per shift (eight hours)?' The evaluation scales were <0.6, 0.6 to 0.7, 0.71 to 0.8, 0.81 to 0.9 and >0.9 m^3.

3.3. Measurement Methods

3.3.1. Principal Component Analysis

Principal component analysis was conducted to examine the link between the latent variables and their indicators, consistent with the exploratory nature of the research goal [43]. This method of analysis is useful for demonstrating convergent and discriminant validity, as well as for reducing the number of variables to consider in subsequent analyses. Key reliability tests, namely, the Kaiser–Meyer–Olkin (KMO) test, Bartlett's test of sphericity, and the Cronbach's alpha test were also performed [44,45]. The Cronbach's alpha test was conducted to examine whether the variables of interest influenced the latent variables. The standard for evaluating the relevance of a model, which is expressed by the failed safety of a scale, is a value exceeding 0.6 [46]. The KMO measure of sampling adequacy and Bartlett's test of sphericity were adopted to assess the reasonability of the exploratory factor analysis (EFA). The recommendations in this respect are $0.5 \leq \text{KMO} \leq 1$ and a significance < 0.05 [44,46].

3.3.2. Relative Autonomy Index

The RAI has been calculated using several scoring formulas that were developed by researchers on the basis of the self-determination continuum (Table 2). The first method involves using the behavioural regulation in exercise questionnaire (BREQ) to determine exercise behaviours and the stages of change occurring during exercise [10]. Here, the RAI calculation entails assigning negative weights to two types of controlled motivation (i.e., external: −2, and introjected: −1) and positive weights to two types of autonomous motivation (i.e., identified: +1, and intrinsic: +2). This method disregards amotivation and integrated regulation because amotivation items exhibit very high skewness; it is also difficult to empirically distinguish between integrated and identified regulation and between integrated and intrinsic regulation. In [11], an amotivation scale was incorporated into RAI measurement through BREQ-2 to measure the continuum of behavioural regulation in an exercise context. The scores of each indicator were weighted and then aggregated to form an RAI: amotivation (−3), external (−2), introjected (−1), identified (+2) and intrinsic (+3). The RAI can also be scored on the basis of the scores computed from all six motivational indicators in BREQ-2R [12]. Accordingly, intrinsic motivation was regarded as the highest form of self-determined motivation and was given a weight of +3; integrated, identified, introjected and external regulation and amotivation were assigned weights of +2, +1, −1, −2 and −3, respectively.

Table 2. Formulas for measuring autonomy via the RAI.

No.	Study	Formula
1	[10]	RAI = ([External × −2] + [Introjected × −1] + [Identified × 1] + [Intrinsic × 2])
2	[11]	RAI = ([Amotivation × −3] + [External × −2] + [Introjected × −1] + [Identified × 2] + [Intrinsic × 3])
3	[12]	RAI = ([Amotivation × −3] + [External × −2] + [Introjected × −1] + [Identified × 1] + [Integrated × 2] + [Intrinsic × 3])

The approaches described above all assign different weights to the motivational indicators in SDT to measure autonomy in physical activity. Specifically, low autonomy levels (i.e., amotivation, external and introjected regulation) are accorded negative weights, whereas high autonomy levels (i.e., identified, integrated and intrinsic regulation) are given positive weights (a process regarded as conventional).

The choice of a specific RAI formula can be explained by two main reasons [17]. First, adopting different scoring protocols may yield additional insights pertinent to the optimal method of combining scores from various motivational instruments or determining which type of motivation is optimal as a key driver of a specific activity. Second, differences in RAI scoring protocols stem originally from context.

The necessity or concrete formula of an alternative index is discussed after the questionnaire results are presented.

3.3.3. Structural Equation Modelling

Structural equation modelling (SEM) was carried out to enquire into the effects of WA on CLP and the relationships between WA and the three basic psychological needs (i.e., examining H1, H2, H3 and H4). To evaluate the goodness-of-fit of the proposed model, we estimated indicators such as the composite reliability (CR) for internal consistency reliability, the indicator loading for indicator reliability and the average variance extracted (AVE) for convergent validity [47]. The structural equation model was examined to test the relationships between the studied variables. The items in the various scales served as indicators of the latent variables in the model. Several indicators were considered: the chi-square ($\chi 2$), the chi-square divided by the degree of freedom ($\chi 2/df$), the comparative fit index (CFI), the Tucker–Lewis index (TLI), the goodness-of-fit index (GFI), the normed fit index (NFI), Akaike's information criterion (AIC) and the root mean square error of approximation (RMSEA).

4. Results

4.1. Factor Analysis and Reliability Test

Table 3 shows the items' factor loadings, derived via the EFA for which the principal axis method with Varimax rotation was adopted. Six components emerged in the consideration of the factor loadings of the final set of 19 motivational items. These six motivational subscales explained 70.597% of the variance, with eigenvalues exceeding 1. The KMO test generated a value of 0.736, and Bartlett's sphericity test derived a statistically significant result ($p < 0.001$). These values confirmed the acceptability of the factor analysis. The internal consistency of the scales was assessed using the following Cronbach's alpha values: introjected regulation = 0.855, intrinsic regulation = 0.841, external regulation = 0.806, amotivation = 0.774, integrated regulation = 0.742 and identified regulation = 0.638. These values exceed 0.6, pointing to the reliability of the six motivational dimensions studied in this work. The scores of the 19 final items under the six motivational subscales were used to calculate the RAI. Specifically, the latent factors were extracted as follows: amotivation on the basis of Amot1, Amot3 and Amot4; external regulation on the basis of Exter2, Exter7, Exter8 and Exter9; introjected regulation using Intro1, Intro2, Intro4 and Intro6; identified regulation on the grounds of Iden2 and Iden5; integrated regulation on the basis of Inte2 and Inte5; and intrinsic regulation using Intri1, Intri4, Intri5 and Intri6.

Table 3. Exploratory factor analysis and reliability of motivational subscales.

Variable	Component					
	Intro	**Intri**	**Exter**	**Amot**	**Inte**	**Iden**
Intro6	0.936					
Intro2	0.936					
Intro1	0.738					
Intro4	0.675					
Intri6		0.836				
Intri1		0.804				
Intri4		0.791				
Intri5		0.752				
Exter2			0.819			
Exter8			0.778			
Exter7			0.770			
Exter9			0.678			
Amot3				0.878		
Amot4				0.838		
Amot1				0.762		
Inte5					0.880	
Inte2					0.874	
Iden2						0.814
Iden5						0.741
Initial eigenvalues	4.57	2.65	2.11	1.51	1.48	1.10
% of variance	24.07	13.93	11.13	7.93	7.77	5.77
Cumulative %	24.07	37.99	49.12	57.05	64.82	70.59
Cronbach's alpha	0.855	0.841	0.806	0.774	0.742	0.638
Mean	3.50	3.38	3.62	1.82	3.51	3.42
Standard deviation	0.825	1.03	0.870	0.367	0.875	0.970
Kaiser–Meyer–Olkin measure of sampling adequacy	0.736					
Bartlett's test of sphericity						
Approx. chi-square	2544.42					
df	171					
Sig.	0.000					

Note: All factor loadings below 0.50 were excluded.

As demonstrated in Table 3, among the six motivational subscales, external regulation was the latent variable for which the participants had the highest score, with a mean (standard deviation (SD)) of 3.62 (0.870). The next highest scores obtained were those on integrated regulation (mean (SD) = 3.51 (0.875)), introjected regulation (mean (SD) = 3.50 (0.825)), identified regulation (mean (SD) = 3.42 (0.970)) and intrinsic regulation (mean (SD) = 3.38 (1.03)). The participants obtained the lowest score on amotivation, with its mean (SD) being 1.82 (0.367). Accordingly, WA was determined using the scoring protocols based on these motivational subscales.

4.2. New Index and Evaluation of Work Autonomy among Onsite Workers

This section details the proposed index for measuring the autonomy of onsite construction workers.

4.2.1. Aggregated Motivation Index

In [12], the researchers raised the important issue of how best to combine the scores obtained using various motivational subscales into one score. To derive the optimum scoring protocol for measuring autonomy at work, we developed an alternative to the RAI on the basis of our results and the following factors:

The first and main factor is the applicability of the simplex concept in Guttman's Radex theory [48] on the ordered relations of correlated variables. Here, the magnitude

of correlations among variables reflects their conceptual similarities. Variables are more similar when they are more highly correlated and vice versa. Specifically, a perfect simplex model evidences its largest correlations along a main diagonal, and these correlations increasingly taper off as one moves away from the diagonal. The results of matrices of correlation between motivational subscales for different work experiences are shown in Tables A1–A3 (Appendix A). These matrices are not considered close to the simplex matrix. The coefficients of correlation between external regulation and intrinsic regulation, as well as those between introjected regulation and intrinsic regulation, were generally high. This means that external, introjected and intrinsic types of regulation were perceived similarly by the workers. More specifically, the correlations imply that the continuum of autonomy advocated in SDT may not hold.

The second factor is related to empirical evidence from [15], which indicated that both autonomous and controlled kinds of motivation positively and significantly contribute to work engagement and productivity among onsite construction workers. The study suggested that controlled motivation advances the perception of autonomy at surveyed sites. This result is consolidated with the first factor discussed above.

The third factor was discussed in [17], wherein the researchers asserted that the item-aggregation approach (i.e., averaging items constituting each individual BREQ subscale, including external, introjected, identified and intrinsic regulation) is the most informative scoring protocol. This suggests that an approach to measuring autonomy via the aggregation of motivational subscales is suitable. Correspondingly, worthwhile tasks are to put forward similar weights associated with these subscales and confirm their validity.

In the SDT framework, autonomous motivation (i.e., identified, integrated and intrinsic regulation) positively contributes to connotations about autonomy, whereas controlled motivation (i.e., external and introjected regulation) negatively contributes to such perceptions. With the above-mentioned reasons as anchor, we developed the aggregated motivation index (AMI) as an alternative measurement of autonomy at work. In the AMI, the scores derived with respect to the two types of controlled motivation and the three types of autonomous motivation are averaged. In other words, the AMI reflects the mean values of five motivational subscales—external, introjected, identified, integrated and intrinsic regulation. Given that amotivation does not contribute to autonomy, it is reasonable to exclude it from the AMI.

As previously stated, few studies have acquired empirical evidence of how the autonomy of construction practitioners can be measured. The current work was therefore conducted to quantitatively measure the WA levels of construction workers using a conventional RAI formula and the proposed AMI. The traditional RAI formula used in [12] (formula no. 3, Table 2) was also employed in the present research because it enables a full evaluation of all possible scoring indicators available within the SDT framework.

4.2.2. Quantitatively Measuring Onsite Workers' Autonomy

This section recounts our quantitative measurement of autonomy among workers, as well as our exploration into the differential effects of the RAI formula and AMI scoring protocol. Table 4 shows the results of the RAI and AMI measurements performed on the basis of various demographic characteristics. The comparison of these measures enabled us to characterise each group of workers and what motivations drive them. This characterisation, in turn, paved the way for discussions of work autonomy from different viewpoints. A low RAI score indicates increased amotivation or controlled motivation, whereas a high RAI score reflects increased autonomous motivation [11]. A high AMI score generally reflects considerable controlled and autonomous motivation, whereas a low score points to the opposite.

Table 4. Measuring the autonomy of workers onsite.

	Category	N	RAI			AMI		
			Mean	SD	ANOVA (sig.)	Mean	SD	ANOVA (sig.)
Gender	Male	187	4.64	3.67	0.009	3.50	0.546	0.588
	Female	28	2.66	4.09		3.44	0.528	
Educational level	Primary school and below	65	4.01	4.00	0.636	3.52	0.515	0.892
	Secondary school	94	4.52	3.59		3.48	0.610	
	High school and above	56	4.58	3.85		3.47	0.456	
Age	≤35 years old	162	4.19	3.81	0.196	3.50	0.544	0.582
	>35 years old	53	4.96	3.62		3.45	0.543	
Work experience	<5 years	94	4.57	3.95	0.283	3.56	0.515	0.004
	5–10 years	84	3.90	3.55		3.52	0.497	
	>10 years	37	4.99	3.78		3.22	0.638	
Marital status	Single	50	4.49	3.73	0.821	3.43	0.603	0.426
	Married	165	4.35	3.80		3.50	0.525	
Income	Low income	95	4.40	3.83	0.957	3.53	0.397	0.310
	High income	120	4.37	3.75		3.45	0.635	
Training	Untrained	182	4.31	3.88	0.524	3.50	0.556	0.533
	Trained	33	4.77	3.12		3.43	0.472	

A one-way analysis of variance (ANOVA) [49] was conducted to delve into whether the RAI/AMI mean scores under various categories exhibit statistically significant differences. The results are shown in Table 4. There are three noteworthy characteristics. First, workers of different genders exhibited significantly different RAI scores. Second, the mean RAI of workers with more than 10 years of experience was the highest, but their mean AMI was the lowest. Workers with various work experiences exhibited significant differences in AMI scores. Third, no significant difference was found with respect to the other demographic variables of interest.

4.3. Influence of Work Autonomy on CLP Improvement and Its Relationship with BPNS

This section presents our analysis of the influence of WA on improving CLP and its association with BPNS.

4.3.1. Development of Structural Equation Modelling

For this examination, we adopted an approach similar to the EFA involving the motivational subscales. Table 5 shows the factor loadings of the EFA-based items; these loadings were determined using the principal axis method. Four components emerged from the factor loadings of the final set of 13 BPNS items and three CLP items. These components explained 73.708% of the variance, with eigenvalues exceeding 1. The KMO test generated a value of 0.836, and Bartlett's sphericity test derived a statistically significant result ($p < 0.001$). These values confirmed the acceptability of the factor analysis.

The latent factors were extracted as follows (Table 5): Autonomy satisfaction was extracted using AS4, AS2, AS1, AS3 and AS5; competence satisfaction was extracted on the basis of CS5, CS4, CS6 and CS2; relatedness satisfaction was extracted using RS1, RS3, RS5 and RS6; and CLP was extracted on the grounds of LP3, LP1 and LP5. Among all three BPNS subscales, competence satisfaction was the latent variable for which the participants gained the highest score, with its mean (SD) being 3.49 (0.809). The next highest scores were those on autonomy satisfaction (mean (SD) = 3.47 (0.855)) and relatedness satisfaction (mean (SD) = 3.35 (0.997)).

Table 5. Exploratory factor analysis and reliability.

Variable	Component			
	AS	**CS**	**RS**	**CLP**
AS4	0.932			
AS2	0.931			
AS1	0.917			
AS3	0.910			
AS5	0.884			
CS5		0.821		
CS4		0.730		
CS6		0.689		
CS2		0.588		
RS1			0.784	
RS3			0.732	
RS5			0.700	
RS6			0.657	
LP3				0.873
LP1				0.775
LP5				0.748
Initial eigenvalues	4.69	4.30	1.54	1.25
% of variance	29.34	26.89	9.63	7.84
Cumulative %	29.34	56.23	65.86	73.70
Cronbach's alpha	0.962	0.804	0.813	0.844
Mean	3.47	3.49	3.35	3.42
SD	0.855	0.809	0.997	0.970
Kaiser–Meyer–Olkin measure of sampling adequacy	0.836			
Bartlett's test of sphericity				
Approx. chi-square	2314.159			
df	120.000			
Sig.	0.000			
Composite reliability (CR)	0.957	0.806	0.814	0.846
Average variance extracted (AVE)	0.818	0.511	0.522	0.648

Note: All factor loadings below 0.50 were excluded.

We analysed the internal consistency of the scales with the Cronbach's alpha values as bases. These values are as follows: autonomy satisfaction = 0.962, competence satisfaction = 0.804, relatedness satisfaction = 0.813 and CLP = 0.844 (Table 5). These exceed 0.6, pointing to the reliability of the study. These latent variables were calculated on the basis of their indications for further analyses.

As shown in Table 5, the CR values of autonomy satisfaction, competence satisfaction, relatedness satisfaction and CLP were 0.957, 0.806, 0.814 and 0.846, respectively. These are greater than the measurement model's threshold of 0.7, indicating the acceptable consistency and reliability of the model. The AVE values were 0.818, 0.511, 0.523 and 0.648, respectively, pointing to a high degree of convergent validity, seeing as they all exceed 0.5 [50].

SEM was adopted to analyse the influence of WA on CLP improvement and the effects of BPNS on WA. The final structural model acceptably fit the data and, overall, performed better than the initial model, as evidenced by the following values: $\chi 2/df = 1.818$, CFI = 0.961, TLI = 0.952, GFI = 0.900, NFI = 0.917, AIC = 287.19 and RMSEA = 0.062 (Table 6). These results demonstrated that all the fit indices satisfied the criteria; thus, the values of the final fit indices in the final structural model suggested the interpretability of the improved model. These findings also confirmed the validity and reliability of the measurement model.

Table 6. Goodness-of-fit results.

Indicator	Recommended Level	Initial Model	Final Model
χ^2/df	from 1 to 2 [51]	2.279	1.818
CFI	0 (no fit) to 1 (perfect fit) [52,53]	0.877	0.961
TLI	0 (no fit) to 1 (perfect fit) [52,53]	0.863	0.952
GFI	0 (no fit) to 1 (perfect fit) [52,53]	0.824	0.900
NFI	0 (no fit) to 1 (perfect fit) [52,53]	0.802	0.917
AIC	Smaller value [54]	615.23	287.19
RMSEA	<0.05, very good fit; 0.05–0.08, fairly good fit; 0.08–0.10, acceptable fit; >0.1, unacceptable fit [55]	0.077	0.062

4.3.2. Quantitative analyses of the influence of WA on CLP and the influence of BPNS on WA

We conducted quantitative analyses of the influence of WA on CLP and the influence of BPNS on WA. Table 7 lists the mean values and standard deviations of the CLP of workers with different work experiences. CLP decreased with increasing experience.

Table 7. Mean and standard deviation of CLP among workers with different work experiences.

	All	Work Experience		
		<5 Years	5–10 Years	>10 Years
Mean	3.42	3.55	3.38	3.18
SD	0.970	0.871	1.02	1.05

Table 8a,b show the results of the regression analyses associated with the four hypotheses. As reflected in the tables, both the AMI and RAI were used to measure WA. The regression coefficients derived using the AMI were statistically significant at $p = 0.001$ for H1, H3 and H4, and those obtained using the RAI were statistically significant at $p = 0.005$ for H1 and H4.

Table 8. (a) Results of regression analyses associated with the four hypotheses (for AMI). (b) Results of regression analyses associated with the four hypotheses (for RAI).

H	Path	All		Work Experience <5 years		5–10 years		>10 years	
		β	*p*	β	*p*	β	*p*	β	*p*
				(a)					
H1	WA → CLP	0.454	***	0.495	***	0.384	***	0.491	0.003
H2	Autonomy satisfaction (AS) → WA	−0.119	0.063	0.001	0.993	−0.123	0.211	−0.397	0.006
H3	Competence satisfaction (CS) → WA	0.287	***	0.338	0.003	0.215	0.046	0.373	0.013
H4	Relatedness satisfaction (RS) → WA	0.352	***	0.183	0.074	0.455	***	0.301	0.082
				(b)					
H1	WA → CLP	0.203	0.005	0.257	0.018	0.153	0.196	0.239	0.166
H2	Autonomy satisfaction (AS) → WA	−0.124	0.066	−0.090	0.393	−0.127	0.202	−0.221	0.161
H3	Competence satisfaction (CS) → WA	−0.023	0.751	0.099	0.388	−0.128	0.226	0.143	0.397
H4	Relatedness satisfaction (RS) → WA	0.247	0.001	0.108	0.307	0.453	***	−0.078	0.671

Note: *** $p < 0.001$.

5. Discussions

On the basis of the results, we identified several valuable features relevant to effective and sustainable construction workforce management.

5.1. First feature: Gender

The ANOVA results revealed significant differences in RAI mean scores (sig. = 0.009) between the genders, but no such variances in mean AMI values were found (Table 4). Specifically, as indicated by their RAI score of 2.66, the female onsite workers had lower autonomy in task completion than that enjoyed by their male counterparts (RAI = 4.64). With respect to the mean values of the motivational subscales of the gender groups (Table A4), the mean intrinsic regulation of the female workers (3.03) was significantly lower than that of their male peers (3.43). In particular, the mean score of the former on 'enjoy finding valuable solutions from team members' (intri6) was 3.00, whereas that of the latter was 3.60.

The mean values of external and introjected regulation among the female workers (3.73, 3.52) were slightly higher than those of the male workers (3.61, 3.49). Among related subscales (Table A5, Appendix A), 'others will respect me more' (exter2) and 'otherwise, feel ashamed of myself' (intro4) are noteworthy. For the first, the male and female workers obtained mean scores of 3.68 and 3.96, respectively. For the second, they obtained mean scores of 3.55 and 3.96, respectively.

These results seem to support a general view of female construction workers in Vietnam that the majority of them work in a construction crew with their relatives; in most cases, with their husbands. Onsite work is recognised as a 'good job' by their families, who very strongly push wives to take on such employment. Thus, the major work motivations of female construction professionals are to receive respect from their families and avoid a sense of shame. Interest in work is not a priority for this group, and the locus of motivation lies outside of them. Put differently, female workers tend to participate in construction tasks to maintain and enhance their role as housewives.

On this basis, then, adopting the RAI as a measure of WA levels is appropriate because this index characterises male and female workers in a clear manner. The use of the AMI blurs the focus of WA with respect to gender. Research on the role of women in the construction domain is rare, and surveys and analyses of WA among female workers are expected to increase in importance once the responsibilities of women in this industry change.

5.2. Second Feature: Work Experience

Two noteworthy characteristics are relevant to work experience: The RAI and AMI scores of the most experienced workers (>10 years) and their least experienced counterparts (<5 years) reflected contrasting degrees of relationships, and statistically significant differences in AMI scores were found among the work experience groups.

5.2.1. Characteristics of the Most Experienced Workers

As shown in Table 4, the RAI score of the most experienced workers (>10 years) was 4.99—the highest among the scores of the three groups (most experienced, moderate experience, and least experienced). The highest RAI arose from the lowest form of controlled motivation. These workers gained scores of 3.18 and 3.18 on external and introjected regulation, respectively. Of particular interest is the contrast between scores with respect to 'receive good support' (exter9) and 'otherwise, feel ashamed' (intro4), with the workers scoring 3.05 and 3.16 on these items, respectively (Table A5, Appendix A). These are significantly lower than the scores of the other two less experienced groups. The most experienced workers earned a score of 3.14 on the item 'rewarded financially' (exter7), which is also significantly lower than those of the other two groups (Table A5, Appendix A). This result may be attributed to the higher incomes of the former, who earn an average of 4369 USD annually. This figure is considerably higher than the average annual income of Vietnamese citizens, which amounted to 2700 USD in 2019. It is also higher than that of the least experienced workers (<5 years, 3610 USD) and the workers with moderate experience (5–10 years, 3792 USD). These results suggest that the locus of work motivation among the most experienced workers does not lie outside.

Furthermore, the most experienced workers scored the lowest in terms of autonomous motivation (i.e., identified, integrated and intrinsic regulation). Their scores on 'try to

improve my skills' (iden2) and 'a chance to learn new things/skills' (intri4) were 3.22 and 3.08, respectively, which are considerably lower than the scores of the other two groups (Table A5, Appendix A). For the most experienced workers, acquiring new skills and displaying enthusiasm in activities diminished in importance. The discussion indicates that although this group was the least constrained by external factors, they were also minimally moved by them.

5.2.2. Characteristics of the Least Experienced Workers

The least experienced workers' (<5 years) RAI score was 4.57, the second highest among the scores of the three groups, as provided in Table 4. They exhibited the highest autonomous motivation out of the groups and higher controlled motivation than that shown by their most experienced peers. They scored 3.69 and 3.64 on the items 'align with my personal values' (inte5) and 'enjoy finding valuable solutions from my teammates' (intri6), respectively. These were the highest scores derived. On the controlled motivation items 'receive good support' (exter9) and 'otherwise, feel ashamed' (intro4), they earned scores of 3.73 and 3.94 (Table A5, Appendix A), respectively, which are considerably higher than those obtained by the most experienced workers. In the RAI, a conventional index of WA, these high scores are counted as negative values. When a newcomer wants to establish himself/herself in the industry, a natural tendency appears to be for this individual to understand and fulfil the expectations of others to avoid disappointing them. Therefore, within substantial autonomous motivation, high controlled motivation represents a development process. The fact that the least experienced workers displayed the highest autonomous motivation and higher controlled motivation than that shown by the other groups implies that pursuing career development as an onsite worker is a favourable start for workers with the least experience in the industry.

5.3. Third Feature: The Important Role of WA in Improving CLP

First, we found a downtrend in CLP with rising work experience (Table 7), in contrast to previous studies [56,57], which discovered a significant impact of the latter on the former. This discrepancy suggests rethinking the practical role of experience in construction workforce management, particularly in CLP improvement.

Second, both the RAI and AMI revealed WA as a positive and significant contributor to CLP (Table 8a,b), but the AMI more accurately explained the influence of the former on the latter (H1; $\beta = 0.405$, $p < 0.001$). This finding reflects that WA, particularly as represented by the AMI, is critical to enhancing CLP. To put it another way, an increase in efforts to ensure WA can significantly contribute to CLP improvement. This finding aligns with prior studies, which found that WA significantly advances work performance among employees of Norwegian service organisations [1] and among hotel staff (e.g., employees and supervisors) in the southern region of South Korea [2]. As WA has rarely been discussed in the construction domain, this finding translates to a new theoretical and practical perspective with respect to how CLP can be improved. It also steers construction managers towards a useful direction in the pursuit of effective construction workforce management.

5.4. Fourth Feature: Enhancing WA by Promoting Satisfaction with Competence and Relatedness

Previous studies neglected the ways by which WA can be cultivated and maintained—a gap bridged in the current research. A comparison of Table 8a,b shows that the AMI could explain the relationship between BPNS and WA. Competence satisfaction (H3; $\beta = 0.287$, $p < 0.001$) and relatedness satisfaction (H4; $\beta = 0.352$, $p < 0.001$) positively and significantly contributed to the WA of the workers. This finding implies that workers' satisfaction with their competence and relatedness increases autonomy at work. Enhanced satisfaction with competence increases the confidence and effectiveness of workers to undertake and participate in tasks, thereby promoting their autonomy. Enhanced satisfaction with relatedness causes workers to feel that they belong to and are part of a larger collective entity wherein valuable interpersonal relationships are cultivated. These feelings, in turn,

promote collaboration among team members and are expected to directly contribute to autonomy improvement at work. The enhancement of satisfaction with competence and relatedness is also a potential mechanism by which autonomy at work can be cultivated and maintained.

We expected the workers' sense of choice and psychological freedom at work to promote their autonomy levels (Table 8b), but autonomy satisfaction did not significantly contribute to WA (H2). This result necessitates a careful consideration of differences in autonomy connotations in autonomous motivation and autonomy satisfaction, as demonstrated in [15]. That is, the autonomy connotation in autonomy satisfaction represents individuals' inherent desire to feel volitional and experience a sense of choice and psychological freedom when carrying out an activity [16], whereas the autonomy connotation in autonomous motivation represents the performance of a task because it is enjoyable, optimally challenging or self-endorsed [19].

5.5. Observations of Career Development among Vietnamese Onsite Workers

5.5.1. General Observations

We used the AMI as an index of WA to validate H1, H3 and H4. We found that the satisfaction of competence and relatedness needs enhanced WA, which in turn improved CLP. However, H2 was not validated, as the actual situation was in complete contrast with the supposition: Autonomy satisfaction may have been perceived as a licence to work 'selfishly', thus exerting a negative influence on WA. This finding provides insight into the career development of Vietnamese onsite construction workers. That is, there was a consistent downtrend in CLP, WA, competence satisfaction and relatedness satisfaction but an uptrend in autonomy satisfaction with work experience. The results imply that newcomers, or the least experienced workers, make a good start in pursuing construction as a career but that their most experienced counterparts are not necessarily successful in terms of career development and are underutilised in the construction industry.

5.5.2. Unsuccessful Career Development and Underutilisation: A Matter of Insufficient Optimal Challenge

By interpreting key statistics, we determined the key impediment to successful career development and the driver of underutilisation among the most experienced workers. In our survey, we focused on the WA of workers performing simple tasks and operated under the assumption that the most experienced workers participating in the survey are involved in such duties. They obtained scores on the items 'feel confident that I can do things well' (CS4; mean value = 3.49) and 'have sufficient work-related skills or knowledge onsite' (CS6; mean value = 3.54) that were as high as those of the other two groups. Their overall autonomy satisfaction score was the highest. They obtained significantly lower scores on overall external and introjected regulation than those of the other two groups, indicating that the most experienced workers have extensive experience in completing simple tasks. They receive recognition from others and are empowered by supervisors as senior workers. They feel a sense of psychological freedom to do these tasks. Correspondingly, respect, financial rewards and support from others are not strong incentives for them because they already enjoy these benefits. They do not have to prove themselves because they are already established professionals.

Nevertheless, they differed in terms of 'face'. Their scores on the items 'can successfully complete difficult or challenging tasks' (CS2; mean value = 3.35) and 'feel effective in what I do onsite' (CS5; mean value = 3.22) are the lowest in their group, which means that they have encountered only limited opportunities to expose themselves to new skills or knowledge. These are considered causes of the fact that they garnered the lowest motivation scores on 'try to improve my skills in my works' (iden2; mean value = 3.22), 'very meaningful for me' (inte2; mean value = 3.27) and 'have a chance to learn new things/new skills (intri4; mean value = 3.08). In summary, a core reason for unsuccessful career development

and underutilisation among the most experienced workers was the insufficient optimal challenge that they had encountered in their career development.

5.6. Policy Recommendations for Enhancing CLP

To enhance CLP as well as workforce management effectively, promoting WA of workers and effective utilization of the experienced workers play an important role. These would stimulate personal happiness, advance their career development and afford these employees industrial benefits. In this respect, we put forward three policy recommendations: the effective organisation of work crew members, the improvement of training and the improvement of site amenities.

5.6.1. Effective Organisation of Work Crew Members

Generally, construction managers tend to assign high-skill tasks to experienced and skilled workers onsite and assign simple or heavy tasks to younger and non-skilled workers. This arrangement can achieve the highest teamwork performance because younger workers inadequately or ineffectively accomplish complicated responsibilities, while experienced and skilled workers may feel discouraged by simple or unchallenging tasks. Non-skilled workers can also improve their experience by accumulating practical skills from skilled veterans. Optimal teamwork in a construction crew necessitates that the composition of skilled and non-skilled workers participating in a task be satisfactorily determined on the basis of task characteristics. In addition to transferring real-world experiences and practical skills to young workers during task implementation, experienced and skilled workers play a vital role in problem solving, which can suddenly occur under uncertain situations onsite, even during the implementation of simple tasks.

In sum, construction professionals should pay more attention to the arrangement or designation of tasks to each worker on the basis of his/her competencies and job characteristics to ensure sufficient optimal challenges for all employees. An optimal challenging task can enable both newcomers and experienced workers to feel excited and enthusiastic about their work, and thereby help them maintain or even enhance their autonomous motivation. Consequently, their WA and CLP can be enhanced.

5.6.2. Improvement of Training

Theoretically, training is a promising way to promote competence satisfaction because workers can acquire the skills necessary to improve their competencies, which in turn elevates their self-confidence and mastery. The survey uncovered that the current training programmes provided to the participating workers are ineffective. As shown in Table A4 (Appendix A), a significant difference in autonomy satisfaction scores was found between trained (mean = 3.89) and untrained (mean = 3.39) workers, but no such difference in competence satisfaction scores existed between them (mean values = 3.46 and 3.49, respectively). These findings suggest the necessity of rethinking the factual role of training in construction workforce management. In Vietnamese construction practice, professional training onsite is very limited. Contractors rarely offer occupational training to their workers because training cost is a primary obstacle, and most tasks onsite typically require little skill and are therefore rapidly learned [58]. Hence, contractors organise only short training courses and only when it is truly necessary, such as when high-skill tasks are to be completed amid the absence of skilled workers who can be recruited for this purpose.

A promising approach to tackling the above-mentioned issues is on-the-job training (OJT). Implementing effective and efficient OJT can give rise to many benefits [59], such as reduced training costs, faster training and adaptation to real-world circumstances and enhanced teamwork. Effective OJT involves experienced workers who are willing to share their practical experiences and problem-solving abilities with their peers. Such sharing can elevate the sense of responsibility among crew members and help them discern their important roles in a crew. Consequently, they become increasingly interested in and

enthusiastic about participating in tasks. This promotes the autonomy at work of workers, which achieves the desired productivity.

5.6.3. Improvement of Site Amenities

In the survey, responses to one question pointed to a serious problem in the Vietnamese construction industry: 'Because I work at safe and healthy conditions' (exter8). The scores of the least and moderately experienced workers on this item were 3.67 and 3.57, respectively, and that of the most experienced workers was 3.08. These differences imply the existence of hazardous working conditions for onsite workers, who are compelled to grapple with unsafe situations and inclement weather. Senior workers are more vulnerable to these undesirable conditions. Sustainable labour management requires safe working conditions. Currently, an important issue in the Vietnamese industry is implementing measures for dealing with heat stress. Solving this issue can help workers work more productively.

Moreover, mobility matters to the construction workforce, and in many cases, workers in a crew not only work together, but also live together on a construction site. Therefore, providing good site amenities (e.g., labour camp facilities, site services and hygiene and sanitation) [60] can advance the establishment of strong ties between team members and supervisors, minimise potential conflicts and ensure harmonious communal living. Under these conditions, workers may feel closely connected with others, rendering them comfortable and happy onsite. A good site amenity also eliminates the risk of occupational diseases, thus ensuring workers' health, particularly among older groups of workers. This contributes to improving their productivity onsite.

5.7. Optimality of Scoring Protocols

This section discusses the optimality of WA scoring protocols. We posit certain conditions as necessary to achieving optimality. Specifically, a given measure should enable the following measures:

1. The separation of groups with different attributes;
2. The characterisation of each group;
3. The further characterisation of each group by identifying the relationship among influencing factors, WA and performance;
4. The identification of latent characteristics (i.e., advantages and disadvantages) and the proposal of improvement measures;
5. The complementing of WA indices.

The RAI and AMI results described in the previous sections highlighted the noteworthy characteristics of each group of workers in terms of gender and work experience. The first four conditions seemed to have been satisfied. For the fifth condition, we proposed a motivation matrix and formulated conceptual and physical interpretations of the RAI and AMI. These perspectives are illustrated in Figure 2.

The motivation matrix consists of two axes: the *x*-axis, which represents controlled motivation (CM), and the *y*-axis, which represents autonomous motivation (AM). Here, controlled motivation can be flexibly calculated on the basis of amotivation, external regulation and introjected regulation: CM = fc (amot, exter, intro). Similarly, autonomous motivation can be calculated with identified, integrated and intrinsic regulation as bases: AM = fa (iden, inter, intri). Correspondingly, the motivational space of workers can be divided into four quadrants.

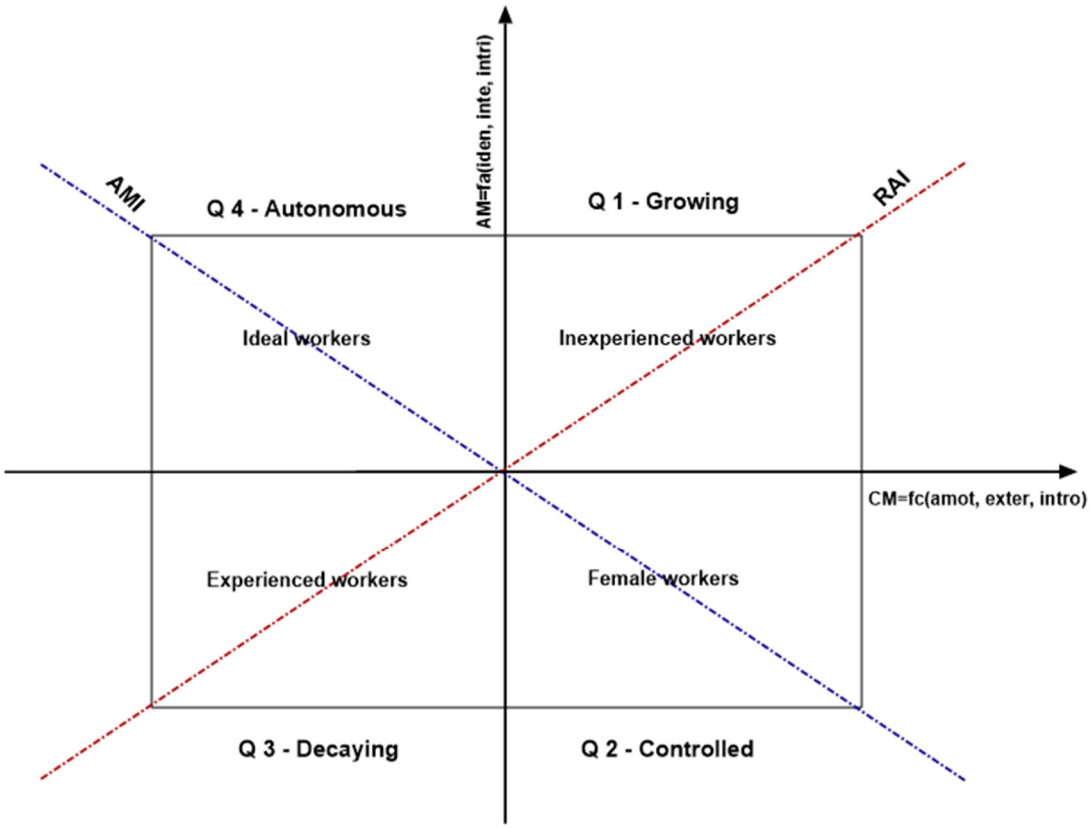

Figure 2. Motivation matrix.

The results and discussions sections showed that the RAI successfully distinguished between the male and female workers, but it could not achieve this distinction in terms of experienced and inexperienced workers because it is insufficiently precise for this purpose. This droves us to develop and introduce the AMI as an auxiliary index. Our results showed that the AMI was sufficiently precise in distinguishing the examined groups on the grounds of work experience. As conceptually visualised in Figure 2, the RAI and AMI generally classified the groups under specific quadrants as follows:

- The inexperienced workers had high controlled and autonomous motivation, locating the largest number of them in the first quadrant. Because they have favourably initiated their career development as onsite workers, we refer to this quadrant as the growing quadrant.
- The female workers had high controlled and low autonomous motivation, positioning the largest number of them in the second quadrant. Because the major driver of construction work among these workers is controlled motivation, we call this quadrant the controlled quadrant.
- The experienced workers exhibited low controlled and autonomous motivation, thus locating the largest number of them in the third quadrant. Because they are not necessarily successful in their career development and are underutilised in the construction industry, we label this quadrant the decaying quadrant.
- The fourth quadrant is called the autonomous quadrant because it represents workers who had high autonomous motivation but low controlled motivation. This situation seems ideal for workers in the construction industry.

In the course of career development, inexperienced workers may move from the first quadrant to the third quadrant, resulting in a decrease in WA and CLP. Thus, in accordance with the motivation matrix, measures should be implemented to ensure that both experienced and inexperienced workers move to the ideal stage in their autonomy,

that is, the fourth quadrant. Inexperienced workers seem to require a given amount of time to move to the fourth quadrant because they are newcomers, even as they have had a good start in their career development. Newcomers are likely to be satisfied with external factors, such as income and respect, which diminish controlled motivation, similar to what transpires among experienced workers. An important measure, therefore, is to help these workers maintain and enhance their autonomous motivation. Put differently, a promising approach is to prevent them from falling into the third quadrant through reasonable policies that can support their successful career development.

As can be seen, the introduction of the AMI, together with the RAI, enabled us to more clearly and comprehensively identify latent and deeply rooted problems, their causes and their potential remedies. This is considered an important aspect of optimality.

6. Conclusions, Implications, and Limitations

This research quantitatively measured the WA of workers by adopting different scoring protocols. A novel model was developed to examine the role of WA in CLP enhancement, and the ways by which WA can be cultivated and maintained through BPNS were explored. Data collected from 215 onsite workers in Vietnam were illuminated via principal component analysis and SEM.

We probed into the effects of different scoring protocols in measuring WA through the RAI and AMI. The AMI was developed and justified as an auxiliary index, and five necessary conditions for determining the optimum WA scoring protocol were proposed. In addition, a motivation matrix was put forward to represent conceptual and physical interpretations of the RAI and AMI. Specifically, the RAI explains differences in WA between genders, while the AMI more precisely accounts for dissimilarities in WA on the basis of work experience. The matrix also revealed the specific attributes of each surveyed group. First, many female workers in Vietnam engage in construction work to maintain and enhance their role as housewives. Second, newcomers are making a good start in their career development. Third, the most experienced workers are less enthusiastic than other groups about participating in simple tasks.

This study significantly contributes to construction workforce management as follows. First, it found that WA plays an important role in improving CLP. Second, its results highlighted the need to pay more attention to the promotion of WA, competence satisfaction and relatedness satisfaction among workers. Third, latent and potentially severe problems of labour management in Vietnam were identified: unsuccessful career development and the underutilisation of experienced workers. Fourth, the study formulated three policy recommendations for solving the aforementioned problems and improving CLP: the effective organisation of work crew members, the improvement of training and the improvement of site amenities. These contributions significantly advance effective and sustainable labour management in Vietnam, with the possibility of being replicated in other countries facing similar problems.

This study also expands existing knowledge on the phenomenon of interest in several respects. To begin with, the AMI was developed and justified as an auxiliary index that can be used to measure WA. Second, five necessary conditions were proposed for the optimality of scoring protocols in WA measurement. Third, the motivation matrix was developed to identify the attributes of each group. These contributions are beneficial to both academics and practitioners in their efforts to definitively and exhaustively identify or explore latent and deeply rooted problems, their causes and potential remedies.

Similar to other studies, the present research is encumbered with certain limitations. It was carried out on a limited scale with 215 rebar and masonry workers in Vietnam, and of this sample, only 37 experienced workers engaged in simple tasks. This casts doubt on the representativeness of the sample in terms of worker and task categories. Further research with larger samples and other work designations should be conducted to collect more representative data and thus derive stronger conclusions. Another limitation is the lack of empirical evidence on the ways by which to promote BPNS. Theoretically, BPNS can

be advanced by introducing a reasonable leadership style, as suggested in [15]. This matter should be addressed in future research. Finally, no empirical corroboration was obtained as to which scoring protocol approach should be adopted to measure autonomy at work among trained and untrained workers. Such studies should prove very useful both from methodological and practical aspects.

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Abbreviations

AS	Autonomy satisfaction
CS	Competence satisfaction
RS	Relatedness satisfaction
WA	Work autonomy
CLP	Construction labour productivity
AM	Autonomous motivation
CM	Controlled motivation
Amot	Amotivation
Exter	External regulation
Intro	Introjected regulation
Iden	Identified regulation
Inte	Integrated regualtion
Intri	Intrinsic regulation
RAI	Relative autonomy index
AMI	Aggregated motivation index
BPNS	Basic psychological needs satisfaction
SDT	Self-determination theory

Appendix A

Table A1. Correlations among the five motivational subscales for the group with <5 years of experience.

	Exter	**Intro**	**Iden**	**Inte**	**Intri**
Exter	1	0.229 *	0.111	0.164	0.236 *
Intro	0.229 *	1	0.115	0.151	0.204 *
Iden	0.111	0.115	1	0.130	0.259 *
Inte	0.164	0.151	0.130	1	0.140
Intri	0.236 *	0.204 *	0.259 *	0.140	1

Note: * $p < 0.05$

Table A2. Correlations among the five motivational subscales for the group with 5–10 years of experience.

	Exter	Intro	Iden	Inte	Intri
Exter	1	0.206	0.098	0.105	0.516 **
Intro	0.206	1	−0.033	0.236 *	0.129
Iden	0.098	−0.033	1	0.007	−0.043
Inte	0.105	0.236 *	0.007	1	0.097
Intri	0.516 **	0.129	−0.043	0.097	1

Note: * $p < 0.05$, ** $p < 0.01$.

Table A3. Correlations among the five motivational subscales for the group with >10 years of experience.

	Exter	Intro	Iden	Inte	Intri
Exter	1	0.430 **	0.244	–0.050	0.573 **
Intro	0.430 **	1	0.483 **	0.056	0.438 **
Iden	0.244	0.483 **	1	–0.084	0.305
Inte	–0.050	0.056	–0.084	1	0.026
Intri	0.573 **	0.438 **	0.305	0.026	1

Note: ** $p < 0.01$.

Table A4. Means and standard deviations of basic psychological needs and motivational subscales.

Category			BSNS			Amot	Controlled		Autonomous		
			AS	CS	RS		Exter	Intro	Iden	Inte	Intri
Gender	Male	Mean	3.47	3.50	3.36	1.81	3.61	3.49	3.42	3.52	3.44
		SD	0.86	0.81	1.01	0.38	0.87	0.85	0.98	0.87	1.02
	Female	Mean	3.43	3.43	3.26	1.94	3.73	3.52	3.43	3.46	3.04
		SD	0.84	0.84	0.95	0.18	0.91	0.60	0.89	0.93	1.08
Work experience	<5 years	Mean	3.37	3.51	3.49	1.87	3.72	3.53	3.47	3.60	3.49
		SD	0.85	0.79	0.93	0.37	0.72	0.84	1.00	0.81	1.03
	5–10 years	Mean	3.51	3.51	3.26	1.85	3.71	3.60	3.47	3.49	3.34
		SD	0.91	0.77	1.09	0.33	0.92	0.70	0.85	0.94	1.04
	>10 years	Mean	3.62	3.40	3.20	1.67	3.18	3.18	3.19	3.32	3.23
		SD	0.70	0.94	0.94	0.42	0.98	0.99	1.13	0.88	1.03
Training	Untrained	Mean	3.39	3.49	3.34	1.86	3.64	3.51	3.43	3.51	3.40
		SD	0.85	0.80	1.02	0.35	0.87	0.85	0.93	0.89	1.04
	Trained	Mean	3.89	3.45	3.39	1.66	3.55	3.42	3.39	3.52	3.28
		SD	0.76	0.85	0.89	0.40	0.90	0.65	1.19	0.80	1.03
Total		Mean	3.47	3.49	3.35	1.82	3.62	3.50	3.42	3.51	3.38
		SD	0.86	0.81	1.00	0.37	0.87	0.82	0.97	0.87	1.03

Table A5. Selected items related to BPNS variables and motivational subscales of the work experience and gender groups.

Observed Item		Work Experience						Gender				Total	
		<5 years		5–10 Years		>10 Years		Male		Female			
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
AS1	I feel that my decisions reflect what I really want.	3.40	0.896	3.55	0.949	3.62	0.721	3.49	0.906	3.57	0.790	3.50	0.891
AS2	I feel my choices express who I really am.	3.33	0.988	3.52	0.950	3.51	0.768	3.45	0.934	3.32	0.983	3.44	0.940

Table A5. *Cont.*

	Observed Item	Work Experience						Gender				Total	
		<5 years		5–10 Years		>10 Years		Male		Female			
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
AS3	I feel I have been doing what really interests me.	3.43	0.967	3.50	0.951	3.70	0.777	3.52	0.918	3.36	1.026	3.50	0.932
AS4	I feel a sense of choice in the tasks I undertake.	3.33	0.932	3.52	0.925	3.59	0.762	3.44	0.928	3.50	0.745	3.45	0.905
AS5	I feel freedom in the tasks I undertake.	3.34	0.887	3.48	1.012	3.65	0.753	3.45	0.923	3.39	0.916	3.45	0.920
CS2	I feel I can successfully complete difficult or challenging tasks.	3.62	1.017	3.56	0.949	3.35	1.160	3.57	0.994	3.39	1.166	3.55	1.017
CS4	I feel confident that I can do things well.	3.53	1.104	3.51	0.963	3.49	1.070	3.52	1.034	3.50	1.106	3.52	1.041
CS5	I feel effective in what I do onsite.	3.32	0.941	3.44	1.010	3.22	1.031	3.36	0.998	3.25	0.887	3.35	.983
CS6	I feel I have sufficient work-related skills or knowledge onsite.	3.55	0.990	3.51	1.024	3.54	1.192	3.53	1.044	3.57	.997	3.53	1.036
RS1	I feel close and connected with other people onsite (e.g., supervisor, teammates).	3.53	1.114	3.19	1.452	3.16	1.191	3.32	1.300	3.46	1.105	3.33	1.275
RS3	I experience a happy feeling with the people I spend time with onsite.	3.34	1.063	3.19	1.285	2.97	1.142	3.26	1.159	2.96	1.232	3.22	1.170
RS5	I experience a comfortable feeling with the people I spend time with onsite.	3.57	1.092	3.36	1.295	3.41	1.404	3.49	1.220	3.29	1.301	3.46	1.229
RS6	My supervisors and teammates help me when I need help.	3.50	1.259	3.30	1.395	3.27	1.217	3.39	1.317	3.32	1.249	3.38	1.305
Amot1	I don't know why I am doing this job; it's pointless to work.	1.81	0.396	1.86	.352	1.73	.450	1.79	.407	1.96	.189	1.81	0.390
Amot3	I don't because I really feel that I'm wasting my time at work.	1.82	0.486	1.81	0.452	1.57	0.502	1.75	0.501	1.89	0.315	1.77	0.483
Amot4	But I do not have a good reason for work.	1.97	0.451	1.88	0.422	1.70	0.463	1.88	0.465	1.96	0.331	1.89	0.450
Exter2	Because others will respect me more (e.g., supervisor, teammates).	3.77	1.052	3.77	1.112	3.46	1.120	3.68	1.099	3.96	0.999	3.72	1.089
Exter7	Because I will be rewarded financially only if I put enough try into my job.	3.72	1.062	3.73	1.022	3.14	1.294	3.61	1.104	3.71	1.150	3.62	1.108
Exter8	Because I work at safety and health conditions.	3.67	.977	3.57	1.235	3.08	1.064	3.52	1.114	3.57	1.136	3.53	1.114
Exter9	Because I received good support from others in my work (e.g., supervisor, teammates).	3.73	.941	3.76	1.082	3.05	1.177	3.62	1.088	3.68	0.945	3.63	1.068
Intro1	Because I have to prove to myself that I can.	3.41	1.231	3.60	1.253	3.00	1.453	3.42	1.306	3.39	1.197	3.41	1.290
Intro2	Because it makes me feel proud of myself.	3.37	1.236	3.69	1.130	3.27	1.347	3.50	1.237	3.36	1.129	3.48	1.222
Intro4	Because otherwise, I would feel ashamed of myself.	3.94	1.133	3.43	1.134	3.16	1.265	3.55	1.188	3.96	1.013	3.60	1.165
Intro6	Because otherwise, I would feel bad about myself.	3.38	1.245	3.69	1.130	3.27	1.347	3.50	1.242	3.36	1.129	3.48	1.226
Iden2	Because I try to improve my skills in my works.	3.61	0.964	3.57	1.045	3.22	1.182	3.52	1.069	3.57	.836	3.53	1.040
Iden5	Because I receive appropriate feedback from my supervisors, teammates.	3.34	1.007	3.37	.903	3.16	0.949	3.33	.941	3.29	1.036	3.32	.954
Inte2	Because it is very meaningful for me.	3.51	1.024	3.65	1.000	3.27	1.170	3.53	1.054	3.46	.999	3.53	1.045

Table A5. *Cont.*

	Observed Item	Work Experience						Gender				Total	
		<5 years		5–10 Years		>10 Years		Male		Female			
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Inte5	Because putting try into this job aligns with my personal values.	3.69	0.949	3.33	1.040	3.38	0.962	3.50	.977	3.46	1.041	3.50	0.984
Intri1	Because it is really important for me.	3.52	1.285	3.33	1.338	3.32	1.132	3.48	1.233	2.96	1.503	3.41	1.279
Intri4	Because I have a chance to learn new things/new skills.	3.46	1.276	3.37	1.210	3.08	1.211	3.38	1.236	3.21	1.287	3.36	1.241
Intri5	Because I would feel there are many benefits to do it.	3.33	1.081	3.20	1.259	3.11	1.100	3.28	1.159	2.96	1.105	3.24	1.155
Intri6	Because I enjoy finding valuable solutions from my teammates.	3.64	1.367	3.44	1.329	3.41	1.322	3.60	1.318	3.00	1.414	3.52	1.342

Appendix B. Measurement of Worker Productivity

For rebar workers (rebar tasks):

- LP1. How many average kilograms of rebar can you process (i.e., cutting, bending, and shaping according to drawn specifications) per shift (eight hours)?
  ^{1}☐ < 150 kg; ^{2}☐ 150–170 kg; ^{3}☐ 171–190 kg; ^{4}☐ 191–210 kg; ^{5}☐ > 210 kg
- LP3. How many average kilograms of rebar can you install and arrange for a column according to drawn specifications per shift (eight hours)?
  ^{1}☐ < 80 kg; ^{2}☐ 80–100 kg; ^{3}☐ 101–120 kg; ^{4}☐ 121–140 kg; ^{5}☐ >140kg
- LP5. How many average kilograms of rebar can you install and arrange for floor according to drawn specifications per shift (eight hours)?
  ^{1}☐ < 60 kg; ^{2}☐ 60–75 kg; ^{3}☐ 76–90 kg; ^{4}☐ 91–105 kg; ^{5}☐ >105 kg

For masonry workers (constructing wall and finishing tasks):

- LP1. How many average cubic meters of straight walls can you build using baked clay bricks per shift (eight hours)?
  ^{1}☐ < 0.6 m^3; ^{2}☐ 0.6–0.7 m^3; ^{3}☐ 0.71–0.8 m^3; ^{4}☐ 0.81–0.9 m^3; ^{5}☐ > 0.9 m^3
- LP3. How many average square meters of wall plaster can you build per shift (eight hours)?
  ^{1}☐ < 4.0 m^2; ^{2}☐ 4.0–4.5 m^2; ^{3}☐ 4.6–5.0 m^2; ^{4}☐ 5.1–6.0 m^2; ^{5}☐ > 6.0 m^2
- LP5. How many average square meters of floor tiling can you build per shift (eight hours)?
  ^{1}☐ < 5.5 m^2 ^{2}☐ 5.5–6.5 m^2; ^{3}☐ 6.6–7.5 m^2; ^{4}☐ 7.6–8.5 m^2; ^{5}☐ > 8.5 m^2

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