Onsite Construction Waste Generation in Sri Lanka: Patterns, Causes, and Policy Implications

Madhavi Herath
Department of Civil Engineering,
Faculty of Engineering,
Sri Lanka Institute of Information Technology,
Malabe, Sri Lanka

Shiromi Karunaratne
Department of Civil Engineering,
Faculty of Engineering,
Sri Lanka Institute of Information Technology,
Malabe, Sri Lanka
*shiromi.k@sliit.lk

Sidni Kumara
Department of Civil Engineering,
Faculty of Engineering,
Sri Lanka Institute of Information Technology,
Malabe, Sri Lanka

Madhushika Senanayake
Department of Civil Engineering,
Faculty of Engineering,
Sri Lanka Institute of Information Technology,
Malabe, Sri Lanka

***Abstract*— The rapid expansion of construction activities worldwide has led to a significant increase in construction waste. It poses substantial challenges to environmental sustainability and economic stability. For effective construction waste management, accurate quantification of onsite waste generation and a clear understanding of the factors contributing to waste generation are required. This study investigates material waste generation across different contractor grades in Sri Lanka, with the following objectives: (1) to quantify and compare onsite material waste generation for key building materials among various contractor grades; (2) to identify and analyse the principal factors influencing onsite construction waste, with a focus on contractor grade differences; and (3) to review prevailing waste management practices among Sri Lankan contractors and propose methodological improvements for future waste reduction. A questionnaire survey was conducted to collect data from multiple contractor grades. Both subjective and statistical analyses of variation were used to examine relationships. The findings revealed differences in waste percentages across contractor grades. Especially in subjective analysis, particularly for key materials such as concrete, sand, aggregate, steel, plastic, and wood. However, statistically, there is no significant difference in total construction waste generation among the various contractor grades. It suggests that all grades contribute comparably to overall waste output. The study identified material handling inefficiencies, design-related issues, and inadequate site management as major contributors to waste. The upper-grade contractors demonstrated more advanced waste management practices. Still, specific improvements need to be made to minimise waste generation in the industry.**

I. Introduction

The construction industry is a cornerstone of economic development and urbanisation worldwide. It is also a leading contributor to global solid waste generation. According to the United Nations Environment Program [1]Construction and demolition activities account for over 40% of global solid waste. Construction waste can be categorised mainly as process waste and demolition waste. Process waste is generated on-site during construction, whereas demolition waste is generated at the end of the building's life. The construction industry is a major contributor to Sri Lanka's economic development. It is a major consumer of natural resources and a generator of onsite waste. The waste generated during construction arises from material handling, storage, cutting, mixing, and installation errors [2]. Recent studies indicate that the material wastage for sand, cement, and timber can reach up to 25%, 14%, and 10%, respectively, in Sri Lanka [3]. This shows the inefficiencies in resource utilisation and site management in the Sri Lankan construction industry.

The capacity and operational practices of the contractor may influence the on-site waste generation. The Construction Industry Development Authority (CIDA) in Sri Lanka classified and registered the contractors. This classification was based on their financial strengths, technical expertise, human resources, and project experience. The gradings range from higher to lower grade, where the classification uses CS1, C1, C2,…, and C9 naming [4]. Higher-grade contractors have access to skilled labour, advanced management systems, and modern equipment, which can contribute to efficient material usage[5]. Conversely, lower-grade contractors may experience higher wastage generation and limited resource access [6].

Understanding the relationship between the contractor grade and the amount of waste generated onsite is important. It allows for identifying the challenges and strengths associated with each contractor grade. It helps contractors minimise the waste generation at construction sites. Furthermore, insights into these dynamics are essential for informing policy and regulatory frameworks. Linking generation patterns with contractor classifications enables effective regulation and sets realistic targets. Thus, developing tailored incentive programs that address the unique needs of different contractor groups is necessary. Examining existing waste management practices among contractors and refining waste examination methods are crucial for practical, evidence-based solutions. Despite the significant role of construction, inefficiencies in material usage and onsite waste generation are critical challenges. Given that contractors are classified into different grades based on their financial and technical capacities, it becomes essential to understand whether these grades influence waste generation patterns and management practices. This raises the research question, "How does contractor grade influence onsite material waste generation and management practices in the Sri Lankan construction industry?" Hence, this study aims to 1. To quantify and compare onsite material waste generation for key building materials across different contractor grades, Sri Lanka, 2. To identify and analyse the main factors contributing to onsite construction waste, with attention to contractor grade differences, 3. To review current waste management practices among Sri Lankan contractors and propose methodological improvements for future waste management.

II. Literature Review

The construction industry is a major consumer of natural resources. The materials used during the construction account for 50% to 60% of the total construction costs [7]. Globally, the sector annually consumes about 25% of wood and 40% of raw stone, sand, and gravel, underscoring the extent of resource extraction [7]. Along with heavy resource usage, the generation of significant onsite waste makes construction waste a dominant contributor to global waste streams. It is estimated that around 40% of the world's waste originates from construction and demolition activities [5].

Globally, various methods have been developed to estimate construction waste. Korea Park et al. (2010) developed a mathematical model to assess construction and demolition waste generation [8]. Fadiya et al. (2014) utilised a quantitative approach based on a questionnaire survey to estimate construction and demolition waste. This method is valuable for gauging perceptions and trends. It relies on subjective responses and is less precise than material reconciliation [9]. More recently, Tong et al. (2023) conducted a systematic review highlighting the growing adoption of predictive methods to improve waste estimation accuracy [10].

In Sri Lanka, Rameezdeen (2006) studied nineteen projects managed by 6 M1-grade contractors. The study calculated waste using material reconciliation as the primary estimation method. This method quantifies the waste generated by comparing store records and actual material requirements. Their findings revealed that sand is the highest-wasting material and identified management inefficiencies as the leading cause [11]. Further, this study could not establish a relationship between contractor grade and waste generated due to the sample's homogeneity [11].

Seneviratne et al. (2015) focused on cement wastage across fifteen buildings. They have used material reconciliation as a method. The results indicate that lower-grade contractors generate higher cement waste and vice versa [12]. However, the analysis was limited to cement; thus, broader conclusions about material waste remain tentative.

Jayawardane (2010) studied how labour arrangement affects construction waste generation. The study examined six building projects under C1 contractors. The results showed that direct labour arrangements led to less waste than sub-contracted labour [13]. However, this study's scope was limited to assessing labour arrangements within a single contractor grade.

Rathnayake et al. (2024) conducted a comprehensive study on construction and demolition waste in Sri Lanka. The study reveals inefficiencies in material use. It emphasises the need for improved waste management practices and guidelines tailored to local conditions [2]. Further, Rathnayake et al. (2024) and Senaviratne et al. (2015) highlighted the need for more granular studies that consider a broader range of materials and contractor grades [12] [2]. Also, Rathnayake et al. (2024) pointed out that Sri Lanka needs to develop specific guidelines and regulatory frameworks that address the estimation and practical management of construction waste [2].

III. Methodology

A. Research Design

A structured questionnaire survey was developed to capture contractors' perspectives regarding on-site construction waste generation. The questionnaire was designed with two main sections: frequency of waste generation and causative factors on construction sites.

Under the material contribution, contractors were asked to evaluate a predefined list of common construction materials. The materials include cement, aggregate, steel, concrete, plastic, and wood. The materials were rated according to how much each contributes to onsite waste generation in their projects. This was designed to identify the materials most frequently associated with waste generation across different contractor grades.

Under the factor assessment, respondents were asked to rate a set of recognised reasons for onsite waste generation. By capturing the contractor's view on the causes, the study aimed to reveal underlying patterns and site-specific challenges that drive waste generation.

Both sections utilised a five-point Likert scale to rate. To ensure consistency and facilitate quantitative analysis. This scaling allowed respondents to express the degree of contribution for each material and reason. It enables the calculation of frequency and severity indices, which were subsequently analysed to determine trends and correlations.

B. Sample Selection

A systematic sampling approach was adopted to ensure the representativeness among different contractors engaged in building construction projects in Sri Lanka. The selection process began by identifying existing contractor grade types and their capacities using the guidelines set by CIDA. This study focuses on the waste generation from the building construction sites, since this is the most significant construction industry according to the annual survey [14].

Five contractor grade types were selected for inclusion in the study. The corresponding financial limits and number of contractors registered in CIDA are summarised below for each grade.

TABLE I. CONTRACTORS REGISTERED IN CIDA

Contract or grade	*Budget (Million LKR)*	*Number of contractors registered*
CS2	$3000 \geq X \geq 1500$	08
C1	$1500 \geq X \geq 600$	27
C2	$600 \geq X \geq 300$	35
C3	$300 \geq X > 150$	61
C4	$150 \geq X > 50$	96

There are a total of 227 contractors registered in CIDA. To determine an appropriate sample size for statistical representativeness, Solvin's formula was applied [15]. According to the formula, the proper sample size should be 144. However, the questionnaire was distributed among 60 contractors due to practical limitations. Of those, 30 completed responses were selected and subsequently used as an adequate sample for the analysis.

C. Material Selection

This study focused on core materials that are essential and frequently utilised on building sites in Sri Lanka. This includes cement, sand, aggregates, steel, concrete, plastic, wood, mixed material, and other miscellaneous waste. The selection was guided by the prevalence of typical construction projects and their contribution to overall waste production.

D. Data Analysis

The following methodological steps were adopted for a structured analysis. The responses were analysed using ordinal logistic regression. It is an appropriate statistical method for modelling ordinal data, such as Likert scale ratings [16]. This approach enabled the estimation of the probability that a respondent from a given contractor grade would select each waste severity category. The likelihood of choosing a particular rating category j (where j = 1,2,3,4,5) was calculated as:

$$Likelihood\ of\ choosing\ category \frac{:\text{Number of respondents choosing category 1}}{\text{Total number of responses received for specific grade}} \quad (1)$$

Each material's frequency index was calculated to summarise the tendency toward waste generation.

$$Frequency\ Index\ (FI) = \sum_{i=1}^{5} \text{wiXi}\ ; wi = \frac{i}{5}. \quad (2)$$

The frequency index was then converted into a percentage to represent the estimated material waste for each contractor grade:

$$Percentage\ of\ material\ waste\ = \frac{\text{Frequency index for a particular material}}{/\text{Total frequency index for the specific category}}. \quad (3)$$

To explore findings from the sample (n=30) to the broader contractor population, the sample-based waste percentages were adjusted for statistical confidence using (4).

$$\{Z = \frac{\text{Ps}-}{\sqrt{\text{P}(1-\text{P})/\text{n}}}\ ; \text{z} = 1.96. \quad (4)$$

According to the confidence level of 95%, Ps is the percentage of material waste for a particular material in the sample, P is the percentage of material waste for a specific material concerning the total population, and n is the sample size.

This analytical framework enables a detailed, statistically sound assessment of material waste generation by contractor grade.

IV. RESULTS AND DISCUSSION

A. Comparison Between Material Waste Percentage and Contractor Grade

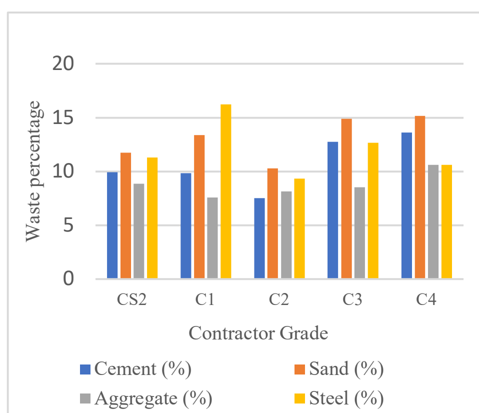

Figure 1. Cement, sand, aggregate, and steel waste generation percentage according to contractor grades

Figure 1 compares cement, sand, aggregate, and steel waste generation across contractor grades. The data reveal that C3 and C4 grades exhibit a higher waste percentage for all four materials, whereas CS2 demonstrates a lower value.

Cement waste percentages are increased in Grades C3 (11.38%) and C4 (12.15%), compared to CS2 (7.25%). Similarly, sand waste is highest for C3 (13.27%) and C4 (13.28%), with CS2 reporting a lower value of 10.48%. Aggregate waste follows this trend, with C3 and C4 at 7.60% and 9.46%, respectively. For CS2, it is only 3.50%. Steel waste peaks in C3 (11.39%) and C4 (9.46%), in contrast to 9.38% for CS2.

These variations are linked to the construction practices adopted by each contractor grade. CS2 contractors typically engaged in large-scale projects. They utilise ready-mixed concrete for the projects. Ready-mixed concrete minimises onsite handling of individual materials and reduces waste generation. Precise procurement and sizing of steel components contribute to lower steel waste generation in CS2 projects.

C3 and C4 contractors are more likely to use site-mixed concrete. On-site concrete mixing increases the amount of material wastage. The higher waste percentages observed underline the impact of inefficient material management and procurement practices.

These findings align with previous research, showing that lower-grade contractors generate higher material waste than higher-grade contractors.

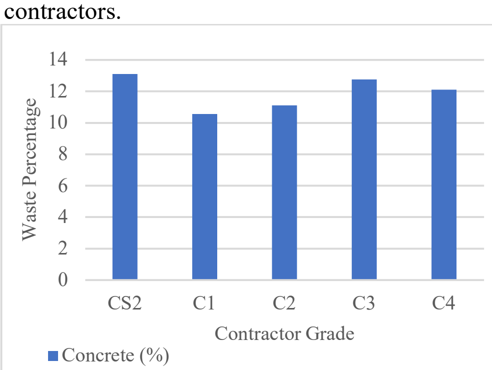

Figure 2. Concrete waste generation percentage according to contractor grades

Figure 2 presents the percentage of concrete waste generated by contractors of different grades. The data reveal that the CS2 contractor grade exhibits the highest concrete waste percentage at 13.21%, followed by C3 (12.76%) and C4 (12.21%). In contrast, the remaining grades, C1 and C2, demonstrate slightly lower and relatively comparable waste percentages.

This trend can be linked to the operational characteristics of each contractor grade. CS2 contractors usually engage in large-scale construction projects. They require substantial quantities of concrete and use pump cars for concrete. Using pump cars for concrete placement in such projects often results in significant initial waste, as a portion of the concrete is lost during the priming and initial pumping process. Furthermore, the strict quality requirements in CS2 projects may lead to rejecting concrete batches.

In comparison, C3 and C4 contractors generally undertake smaller-scale projects. They usually use site-mixed concrete, producing only the quantities required for immediate use. This practice minimises excess and reduces the likelihood of large-scale waste. Additionally, lower-grade contractors may place less emphasis on strict quality control, resulting in fewer rejections. However, the relatively high waste percentage observed in C3 contractors may indicate inadequate onsite waste management practices. Improving material handling and process controls is important for all grades.

Figure 3. Plastic and wood waste generation percentage according to contractor grades

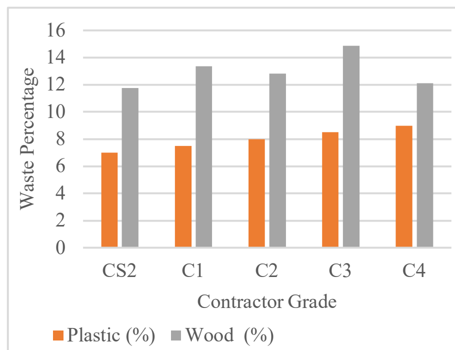

Figure 3 illustrates the waste percentages for plastic and wood among different contractor grades. The data indicate that CS2 contractors have the lowest waste percentages. The plastic waste is 6.55%, and the wood waste is 7.96% in CS2 projects. The highest waste percentages are observed in lower-grade contractors, particularly C3 and C4. Their plastic waste is 8.38% and 9.06%, and wood waste percentages are 14.89% and 12.12%, respectively.

These differences may be because the higher grade contractors use waste management practices, such as the 3R system—Reduce, Reuse, and Recycle. Implementing the 3R system is common among CS2 contractors in Sri Lanka. This approach reduces plastic consumption and mi

nimises disposal.

Higher-grade contractors, such as CS2, frequently reuse timber components until they are no longer serviceable. It significantly reduces the amount of wood waste generated onsite. Lower-grade contractors (C3 and C4) lack proper waste management protocols, and the efforts for reusing and recycling are lower. The absence of alternative material usage and insufficient adherence to waste minimisation strategies contribute to elevated wood and plastic waste percentages.

B. Comparative Analysis of Factors Contributing to Construction Waste by Contractor Grade

This section examines the relationship between contractor grade and the factors contributing to the construction waste generation in Sri Lanka. The analysis is based on five key factors as mentioned below.

A – Design-related issues (design errors, contract document errors)
B – Material handling inefficiencies (damage during transport, off-loading, onsite distribution, improper storage)
C – Weather-related damages
D – Material misplacement on site
E – Other factors (lack of site material control, inadequate waste management plans)

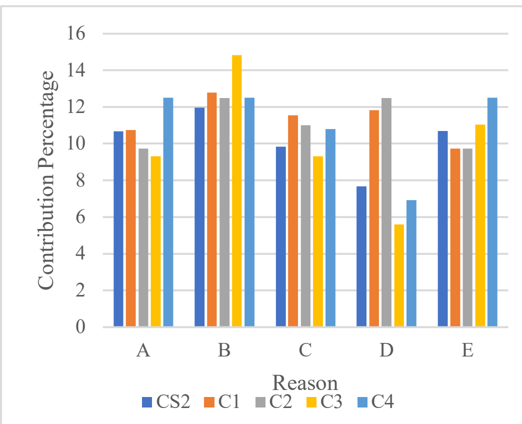

Figure 4. Average response percentage for each factor by contractor grade.

The average response percentages for each factor by contractor grade are presented in Figure 4. The data indicate that design-related issues (Reason A) contribute the most among C4 contractors (12.52%). CS2 contractors make a lower contribution (10.67%). Middle-grade contractors (C1, C2, C3) exhibit moderate values. This emphasises that design and documentation errors are frequent in lower-grade projects.

Material handling inefficiencies (Reason B) are high in C3 contractors (14.83%). For CS2 contractors, it is 11.97%. This indicates that lower-grade students have challenges in managing materials efficiently. Their less developed logistics and storage practices may contribute to that.

Weather-related damage (Reason C) is highest in C1 contractors (11.54%), with other grades demonstrating less variation. This finding underscores the need for improved weather mitigation strategies and improved storage facilities.

Material misplacement on site (Reason D) is high among CS2 contractors (7.68%), possibly linked to their projects' scale and complexity. C3 and C4 contractors report lower contributions (5.60% and 6.93%, respectively).

Other factors, including inadequate site materials control and waste management plans (Reason E), are most significant among C4 contractors (12.52%), while CS2 contractors report a lower average (10.69%). Higher-grade contractors implement effective site control and waste management practices.

The CS2 contractors report lower or moderate percentages for waste-generating factors. This reflects their adoption of advanced management practices, higher standards, and quality control measures. Conversely, lower-grade contractors (C3, C4) display higher contributions from design errors, material handling inefficiencies, and poor waste management. This emphasises the need for targeted improvements in these areas.

While higher-grade contractors demonstrate more effective waste minimisation practices, the findings highlight the necessity for industry-wide enhancements. Especially in design processes, material handling, and site management, to achieve meaningful reductions in construction waste across all contractor grades.

C. Review of Current Waste Management Practices and Recommendations for Improvement

Analysis of responses indicates that waste management practices vary considerably. Higher-grade contractors (CS2, C1) implement more structured waste management strategies. Some of those strategies are the centralized collection of onsite waste and distribution to subcontractors for disposal at designated landfill sites. They align with the practices observed in European countries. Most of their construction waste is recycled and reused where feasible.

Material-specific practices are also evident. For example, steel offcuts are typically returned to steel mills for recycling. Timber formwork is reused multiple times before being repurposed, often as firewood. Adopting system formwork among CS2 contractors has further reduced timber waste generation.

However, the substantial requirement

The use of landfill disposal highlights the limitations of current waste reduction methods. For advanced waste minimisation, it is recommended that Sri Lankan contractors adopt innovative design strategies. Dimensional coordination to reduce material offcuts and increase the use of alternative, sustainable materials can be implemented. Developing and enforcing comprehensive site waste management plans and industry-wide education on best practices are essential for waste reduction.

V. Conclusion and Recommendations

This study has estimated waste percentages for various construction materials across five contractor grade types. These findings represent approximate values based on the selected sample and methodology. The study revealed that material waste generation percentages vary among contractor grades. The lower-grade contractors (C3 and C4) generally exhibit higher waste percentages for key materials such as cement, sand, and wood, while higher-grade contractors (CS2 and C1) demonstrated comparatively lower waste due to better management practices and the use of ready-mixed concrete. Major contributing factors to waste included material handling inefficiencies, design changes, and inadequate site control. However, statistical analysis indicated that overall waste generation across contractor grades was comparable, suggesting that all contractor types contribute significantly to construction waste. The following methodological improvements are recommended to enhance the accuracy and reliability of future assessments.

A. Integrate Multiple Estimation Methods:

Combining questionnaire survey and material reconciliation methods will enable a more robust and accurate determination of material-specific waste rates.

B. Increase Data Resolution Within Projects:

Collecting multiple stakeholder questionnaire responses will capture various perspectives and operational practices. It enables a comprehensive analysis.

References

[1] U. N. Environment, “Global Status Report for Buildings and Construction 2024/2025 | UNEP - UN Environment Programme.” Accessed: Jul. 03, 2025. [Online]. Available: https://www.unep.org/resources/report/global-status-report-buildings-and-construction-20242025

[2] R. M. L. D. Rathnayake, R. M. L. Madushantha, W. A. P. C. P. Gunawardhana, and P. B. R. Dissanayaka, “Unveiling Construction and Demolition Waste Dynamics: A Case Study of the Building Construction Sector in Sri Lanka,” *Eng. J. Inst. Eng. Sri Lanka*, vol. 57, no. 4, pp. 47–54, Nov. 2024, doi: 10.4038/engineer.v57i4.7665.

[3] R. M. L. D. Rathnayake, R. M. L. Madushantha, W. A. P. C. P. Gunawardhana, and P. B. R. Dissanayaka, "Unveiling Construction and Demolition Waste Dynamics: A Case Study of the Building Construction Sector in Sri Lanka," *Eng. J. Inst. Eng. Sri Lanka*, vol. 57, no. 4, Nov. 2024, doi: 10.4038/engineer.v57i4.7665.

[4] “Registration and Grading Scheme.” Accessed: Jul. 08, 2025. [Online]. Available: https://www.cida.gov.lk/sea_con/pages_e.php?id=124

[5] U. Kulatunga, R. D. G. Amaratunga, R. Haigh, and D. Rameezdeen, “SOURCES OF CONSTRUCTION MATERIAL WASTAGE IN SRI LANKAN SITES”.

[6] T. Khaleel and A. Al-Zubaidy, “Major factors contributing to the construction waste generation in building projects of Iraq,” *MATEC Web Conf.*, vol. 162, p. 02034, 2018, doi: 10.1051/matecconf/201816202034.

[7] C. Rose and J. Stegemann, “From Waste Management to Component Management in the Construction Industry,” *Sustainability*, vol. 10, p. 229, Jan. 2018, doi: 10.3390/su10010229.

[8] J. Park, J. Kim, and S. Lim, "Quantitative estimation of construction and demolition waste in Korea using a prediction model," *Waste Manag.*, 2010.

[9] O. Fadiya and E. Chinyio, “Quantitative Analysis of the Sources of Construction Waste,” *J. Constr. Eng.*, vol. 2014, Oct. 2014, doi: 10.1155/2014/651060.

[10] N. Tong, N. Domingo, and A. T. H. Le, “Construction waste estimation methods: a systematic literature review,” in *11th World Construction Symposium - 2023*, Ceylon Institute of Builders - Sri Lanka, Jul. 2023, pp. 420–431. doi: 10.31705/wcs.2023.35.

[11] Rameezdeen, R., "Material waste in Sri Lankan construction industry: A survey." *Eng. J. Inst. Eng. Sri Lanka*, vol. 39(3), pp. 23-30, 2006.

[12] K. Seneviratne, R. Rameezdeen, and P. Amaratunga, “Contractor Capacity and Waste Generation: An Empirical Investigation,” vol. 20, pp. 25–36, Dec. 2015.

[13] Jayawardane, A. K. W.., "Construction and demolition waste management: Current practices in Sri Lanka." In *Proceedings of the International Conference on Sustainable Built Environment*, 2010, pp. 112–119.

[14] “CIDA - Annual Report 2021.pdf.” Accessed: Jul. 13, 2025. [Online]. Available: https://www.cida.gov.lk/content/files/publications/CIDA%20-%20Annual%20Report%202021.pdf

[15] M. Momin, *Determination of Sample Size for data collection*. 2025.

[16] B. Zumbo and C. Ochieng, “The Effects of Various Configurations of Likert, Ordered Categorical, or Rating Scale Data on the Ordinal Logistic Regression Pseudo R-Squared Measure of Fit: The Case of the Cummulative Logit Model,” Jan. 2002.