# An empirical investigation of the determinants influencing consumers' planned choices of eco-innovative materials

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**Abstract:** Wood-polymer composites (WPCs) are eco-innovative materials combining wood and plastics. Due to the novelty, little is known about consumer acceptance. Investigating the drivers of consumers' WPC choices reveals consumers' perception of the materials' advantages over competing ones. The predictors of WPC acceptance were examined within a theory of planned behaviour (TPB; Ajzen, 1991) framework. An online survey ($N$ = 357), varying material x appearance within and product category between subjects, was conducted in Germany. Structural equation modelling revealed that the attitudes towards environmental and innovative product aspects and the subjective norm explain the intention to buy WPC products ($R^2$ = 0.56). Consumers' choice behaviour was assessed with a choice-based conjoint analysis (CBCA) and predicted by the behavioural intention and perceived behavioural control (PBC) ($R^2$ = 0.39). Hence, the present study identifies important drivers of WPC acceptance that could be useful for deriving certain marketing implications, potentially fostering more eco-friendly consumption.

**Keywords:** green marketing; composites; eco-innovation; theory of planned behaviour; conjoint analysis.

**Reference** to this paper should be made as follows: Osburg, V-S. (xxxx) 'An empirical investigation of the determinants influencing consumers' planned choices of eco-innovative materials', *Int. J. Innovation and Sustainable Development*, Vol. x, No. x, pp.xxx–xxx.

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## 1 Introduction

Efficient resource utilisation has gained increasing importance owing to a competition for limited resources. At the same time, the various environmental problems that face humanity necessitate eco-friendly solutions. Therefore, materials have been developed to fulfil both the needs for competition and the sustainability. These eco-innovative materials have several advantages such as a diverse range of environmental benefits, cost-savings because of less resources being used and market competitiveness (Crabbé et al., 2013; Lin et al., 2013; Medeiros et al., 2014). Even though they are promising, these materials will fail without achieving consumer acceptance. An important contribution to eco-innovative materials' success can therefore be made by green marketing, which is defined as the "holistic management process responsible for identifying, anticipating and satisfying the needs of customers and society, in a profitable and sustainable way" (Peattie and Charter, 2003, p.727). Hence, marketing should find out consumers' (product) requirements by also taking environmental concerns into consideration. These issues should be addressed by emphasising the product's benefits and by simultaneously meeting the concerns of consumers.

A group of eco-innovative materials are WPCs, which consist of wood (up to more than 80%), plastics and additives (Klyosov, 2007). These materials are claimed to represent an innovative approach, facilitating sustainable and efficient resource utilisation (Suttie, 2007). Although extensive research has been carried out in the material sciences on a continuous material improvement (e.g., Ashrafi et al., 2011; Bledzki and Faruk, 2003; Kuo et al., 2009), only a few studies have attempted to examine consumer acceptance of WPC products (e.g., Jonsson et al., 2008; Osburg et al., 2014, 2015b; Weinfurter and Eder, 2009). While some consumer studies focused merely on the acceptance of WPCs, and others focused on the dependence of a material's appearance (Osburg et al., 2014, 2015b) and also identified innovative and environmentally concerned consumers as important target groups for WPC products (Osburg et al., 2015b), it is necessary to comprehensively analyse the determinants of consumer acceptance. Thereby, it is important to choose an approach that allows for the assessment of the new material in relation to its most competing materials (Osburg et al., 2014, 2015b). Identifying the determinants finally allows for the definition of certain factors that could increase consumer acceptance of WPC products. The investigation has to be carried out in relation to solid wood and full plastics, since the eco-innovations can substitute both traditional materials. Hence, this paper aims to examine the predictors, taking recourse to a theoretical framework using the TPB (Ajzen, 1991).

## 2 Literature review

### *2.1 Consumer acceptance of wood-polymer composites*

WPCs are eco-innovative materials, which try to combine the advantages of two of the most important materials, wood and plastics (Schwendemann, 2008).[1] While it is partially possible to utilise WPCs similar to wood, an extrusion comparable with plastics leads to uniform materials and appearances (Suttie, 2007). Contrary to solid wood, WPCs require low maintenance and have been discussed as having a superior durability for outdoor

applications, resulting in lower life-cycle costs (Caufield et al., 2005; Pritchard, 2004; Suttie, 2007). Additionally, in comparison with wood, WPCs are characterised by lower water absorption and the absence of splintering (Caufield et al., 2005; Pritchard, 2004). Compared with plastics, WPCs are thermally more stable and are especially promising when taking into account the increasing prices of fossil fuels, which are used to manufacture plastics (Carus et al., 2008, 2014; Eder and Carus, 2013; Suttie, 2007).

In the face of eco-friendliness and resource efficiency, both established materials show some disadvantages. Ecological advantages of WPCs not only emerge in comparison with fossil-fuel-based plastics, which are typically acknowledged as being environmentally hazardous, but also when compared with solid wood. Products consisting of solid wood are typically perceived as being eco-friendly. However, WPCs also possess environmental advantages compared with solid wood, as these materials mainly substitute tropical timber, a sensitive resource, which is often used for outdoor decking (Carus et al., 2008; Eder and Carus, 2013). In light of resource efficiency, it has to be acknowledged that solid wood, in general, consumes a large amount of resources in mass production. As a huge variety of wood waste and wood by-products can be used for the production of WPCs, these materials provide a new opportunity for the timber industry to experience a production with almost no waste, thereby realising additional material utilisations of resources prior to a conversion into energy (Carus et al., 2008; Teuber et al., 2015). To achieve a further improvement of WPC eco-friendliness, several studies currently try to address factors influencing a better recyclability of WPCs (e.g., Beg and Pickering, 2008a, 2008b; Petchwattana et al., 2012; Shahi et al., 2012).

Despite all these advantages, consumer acceptance of WPCs is disputable, owing to the conjunction of contradictory perceived constituents, wood and plastics, the latter typically associated with health and environmental concerns as well as inferior quality (Eyerer et al., 2010; Petrescu et al., 2010). The potential challenge that consumers might be concerned about WPCs is also suggested by the prediction of consumers' intention to buy plastic lumber, which is a material consisting of virgin or recycled plastics. Singh (2010) mentioned that although plastic lumber is superior to solid wood in several aspects (e.g., maintenance, splintering), consumers perceive plastics as inferior to wood, which requires a considerable marketing effort to convince potential consumers of the benefits of plastic lumber. Hence, the material aspects valued by consumers have to be investigated and used for the marketing of materials such as plastic lumber or WPCs. It seems to be important that consumers recognise how these materials differentiate from competing materials as consumers' perception of product advantages has been identified as an important driver of new product success (Henard and Szymanski, 2001).

### *2.2 Predicting consumer behaviour using the theory of planned behaviour*

The TPB and its predecessor, the theory of reasoned action (TRA; Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975), are important theories for analysing behavioural choices (Chatzidakis et al., 2007; Groot and Steg, 2007; Vermeir and Verbeke, 2008). Amongst others, successful applications are related to the prediction of various forms of eco-friendly (consumer) behaviour, including sustainable and organic food consumption (Nocella et al., 2012; Vermeir and Verbeke, 2008), choices of eco-friendly hotels and restaurants (Han et al., 2010; Kim et al., 2013), acceptance of green energy (Litvine and Wüstenhagen, 2011; Read et al., 2013), use of public transportation (Donald et al., 2014;

Groot and Steg, 2007), implementation of recycling (Chan and Bishop, 2013; Park and Ha, 2012; Rhodes et al., 2014; Wan et al., 2014), reduction of resource consumption (Richetin et al., 2012; Webb et al., 2014) and the purchase of solid wood products (Kalafatis et al., 1999). The superiority of the TPB over competing theories, e.g., Value-Belief-Norm Theory (Stern et al., 1999; Stern, 2000), has been proven for the explanation of eco-friendly behaviour (e.g., Kaiser et al., 2005; López-Mosquera and Sánchez, 2012). Owing to the empirical evidence showing that the TPB is suitable for identifying the drivers of eco-friendly (consumer) behaviour and as the choice of an eco-friendly product represents a deliberative decision (Follows and Jobber, 2000), this model is chosen to investigate the determinants of consumer acceptance of eco-innovative materials.

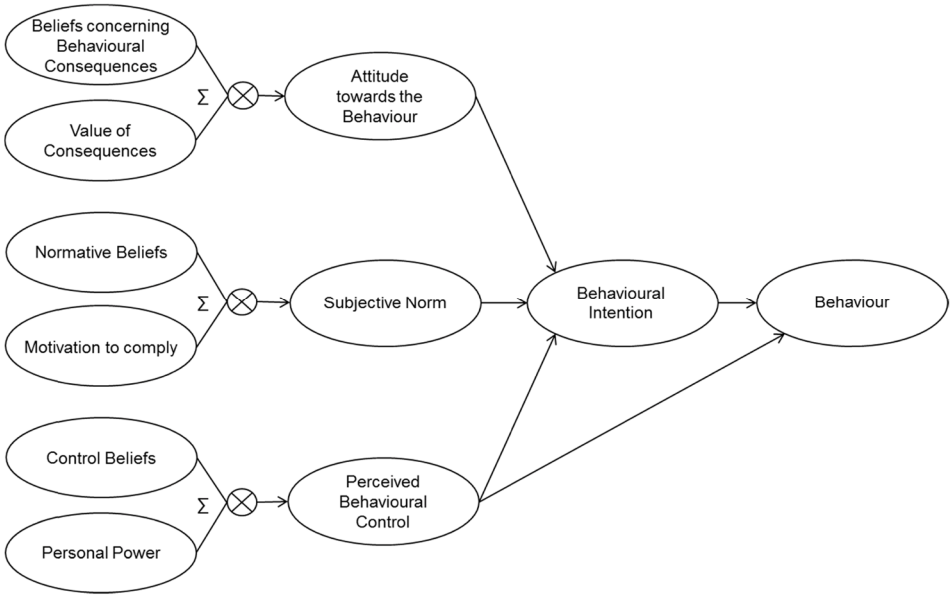
An important assumption of the TPB (Figure 1) is that the *intention* to perform a behaviour is the immediate antecedent of behaviour execution. The intention is generally understood to subsume all motivational factors driving an individual to be consistent with the investigated behaviour, therefore representing a measure of an individual's effort or willingness to try to engage in a specific behaviour (Ajzen, 1991). Thereby, the intention serves as a mediator between three conceptually independent behavioural determinants and the behaviour, whereby the importance of the predictors varies according to the investigated behaviour (Ajzen and Fishbein, 2005): a positive or negative evaluation of the considered behaviour (*attitude towards the behaviour*), the perceived social pressure to perform or suppress the behaviour (*subjective norm*) as well as an individual's perceived ease or difficulty to carry out the behaviour (PBC). Besides, PBC is the only driver of the intention with an additional direct influence on the behaviour, given that the PBC corresponds with an individual's actual control. In general, the stronger the attitude and the subjective norm, and the greater the PBC, the higher an individual's behavioural intention will be. Also, the higher the behavioural intention is, the more likely an individual will transform the intention towards behaviour execution (Ajzen, 1991; Hrubes et al., 2001). However, as difficulties might arise when conducting a specific behaviour, the PBC representing a proxy for the actual control should be considered as a second direct determinant of the behaviour execution (Hrubes et al., 2001). The addition of PBC as a driver of the behavioural intention distinguishes the TPB from its predecessor, the TRA. Considering the PBC became fundamental, as the TRA did not satisfactorily predict behaviours over which individuals have only limited volitional control (Ajzen, 1991). Hence, the TPB is superior over the TRA for investigations where the behaviour under consideration is restricted by certain factors, e.g., time, effort and money.

Another main assumption of the TPB is that an individual's behaviour follows reasonably from his or her salient beliefs (Ajzen, 1991), while recent research has supported the importance of beliefs for predicting eco-friendly consumer behaviour (Pagiaslis and Krystallis, 2014). More precisely, Figure 1 illustrates that all three determinants of the intention are formed based on an Expectancy (belief strength) – Value (evaluation) Theory approach: The *belief strength* refers to the subjective probability that a behaviour will result in a specific outcome (Fishbein and Ajzen, 1975) and is weighted by an individual's *evaluation* of the associated outcome (Ajzen, 1991; Ajzen and Fishbein, 2005). Subsequently, the products are aggregated (Ajzen, 1991), resulting in the three antecedents of the intention. Calling the attitude towards the behaviour $A$, it is determined by the following equation (Ajzen, 1991; Fishbein and Ajzen, 1975):

$$A \propto \sum_{i=1}^{n} b_i e_i$$

with the strength of each belief (*b*) being multiplied with an individual's evaluation (*e*). This approach assures that not only the strengths of the beliefs are considered, but also the values an individual ascribes to the expected outcomes.

**Figure 1** The theory of planned behaviour




*Source*: According to Ajzen (1991)

As with all theories, the TPB has been confronted with limitations. Among these are questioning the sufficiency assumption for predicting behaviour and the low variance, which could be explained in actual behaviour in some studies (Ajzen, 2011). Because of this, Ajzen and Fishbein (2005) stated that the TPB is open to the inclusion of additional predictors of the behavioural intention. Even though various constructs have been added to the TPB's three main determinants, e.g., past behaviour (Read et al., 2013; Richetin et al., 2012; Webb et al., 2014), perceived self-efficacy (Litvine and Wüstenhagen, 2011), descriptive norm (Donald et al., 2014) and moral norm (Chan and Bishop, 2013; Donald et al., 2014; Wan et al., 2014), none of these have been established so far. Another challenge refers to the assumption that the TPB neglects emotional responses by being a theory, which builds on reasoned behaviour (Ajzen, 2011). However, though it is assumed that an individual's behaviour follows reasonably from beliefs and the associated evaluations, the TPB does not suppose that an individual's beliefs are fully rational (Ajzen, 2011; Ajzen and Fishbein, 2005). Although taking these limitations into account, applying the TPB to predict green consumer choices seems to be justified and preferable over selecting competing theories (Kaiser et al., 2005; López-Mosquera and Sánchez, 2012).

The purpose of this study is therefore to develop an understanding of WPC acceptance in relation to the established materials of solid wood and full plastics by testing all the TPB components as comparative scores. Hence, the expectancy of an outcome of a WPC purchase is compared with the expectancy of the same outcome owing to a solid wood or full plastics purchase: b_comp.WPC = b_WPC-mean(b_wood, b_WPC, b_plastics). Appearance has to be considered since it is discussed as an important driver of consumers' intention to purchase WPC products (Osburg et al., 2014, 2015b). WPCs could either look like plastics or solid wood, with the appearance being dependent on the materials' composition and the wood species being used (Clemons, 2008; Pritchard, 2004). According to the TPB, it is expected that behavioural intention serves as a mediator between three conceptually independent behavioural determinants and the behaviour ($H_1$). Additionally, as two main characteristics of WPCs are their eco-friendliness, as well as their innovativeness (Osburg et al., 2015b), it is further assumed that the distinct attitudes towards environmental product aspects and innovative product aspects have to be separated in the TPB framework. On the basis of this assumption, it is hypothesised that the attitude towards environmental product aspects ($H_2$) as well as the attitude towards innovative product aspects ($H_3$) influence consumers' purchase intention in addition to the subjective norm and the PBC.

## 3 Methods

### *3.1 Participants and procedure*

Data were collected from 13 to 19 December, 2013. Drawn from a commercial panel (Global Market Insite, Inc.), 513 respondents representative for the German population participated in an online survey to assess their purchase intention. Some respondents had to be excluded from data analysis because they had missing answers owing to leaving the survey early or they had crisscrossed the questionnaire, leading to a lack of intra-personal variance. Because of this, data of 156 participants had to be deleted, resulting in an adjusted sample size of 357. Appendix A presents the sample characteristics. The mean age was 48.45 years ($SD$ = 15.91) and gender was distributed nearly equally (46% male respondents). WPCs were unknown for 60% of the respondents prior to their participation, while 37% knew the term from hearsay and only 3% reported good material knowledge.

The experimental design was set as follows: material (solid wood, WPC, full plastics) and appearance (wooden, synthetic surface) were varied within and product category between subjects (chair, window frame and fence). Three different product categories were selected so that the range of the investigated products was broadened to ensure generalisability among products consisting of WPCs. Hence, product category was used to repeat the survey for different WPC applications. Chairs, window frames and fencing were chosen as product categories because construction (e.g., decking, siding and fencing) is currently the most important sector for WPC applications (Carus et al., 2014). Nevertheless, a growing importance of WPC furniture and other WPC construction applications such as window frames and doors has been predicted for the next decade as the traditional WPC application of decking reached the maturity stage in the European market (Carus et al., 2014; Eder and Carus, 2013).

Participants were randomly assigned to one of the three product categories. In the beginning of the survey, respondents received information about the product's material and appearance: a) wood: 'solid wood'; b) WPC: "Wood-Plastic-Composite: 70% wood (mainly wood by-products, e.g., sawdust), 30% plastics, additives", and c) polymers: "Synthetically produced material ('plastics'): mineral oil, coal, natural gas". Additionally, six photographs were shown to each respondent, depending on the assigned condition (i.e., chair, window frame or fence) to illustrate the two appearances (brown synthetic vs. brown wooden chair; white synthetic vs. brown wooden window frame; white synthetic vs. brown wooden fence). The photographs of the three materials within a given appearance level and product category were identical. Overall, participants were therefore introduced to six different product variants, which are given in Table 1, exemplarily for 'chair' as the assigned product category. During the following questionnaire, respondents had to answer those items that referred to the product, six times, i.e., once for each of the six product variants. This procedure followed the principle of compatibility between attitude and intention, to achieve a good prediction of an individual's behavioural intention (Ajzen and Fishbein, 2005).

**Table 1** Overview of the six product variants introduced to each participant, exemplarily for 'chair' as assigned product category

| | *Appearance* | |
|---|---|---|
| *Material* | *Wooden* | *Synthetic* |
| Solid wood | Wooden chair | PVC chair, veneered |
| WPC | WPC chair | WPC chair |
| Plastics | Wooden chair, laminated | PVC chair |

## *3.2 Measures*

The online survey consisted of several parts, whereupon this paper refers to the assessment of the TPB constructs, including a CBCA and socio-demographic information.

The TPB items were developed based on literature research comprising: I) an identification of the relevant material characteristics, II) studies showing the effects of specific material properties on consumer decisions, and III) TPB studies about eco-friendly consumer behaviour. This resulted in the contents of the attitude (environmental aspects and innovative aspects), subjective norm and PBC items. On the basis of these sources, expectancy and value component items were formulated. Appendix B documents the revealed items and the corresponding references.

Participants estimated the likelihood of the expectancy components (i.e., behavioural beliefs, normative beliefs and control beliefs) on 5-point-scales ranging from '0% / never applies' to '100% / always applies'. Respondents were requested to assess the value components (i.e., value of consequences, motivation to comply and personal power) on 7-point scales, ranging from −3 (bad) to +3 (good). While it was sufficient to assess each value component only once per participant, the expectancy components were measured for each combination of material and appearance, resulting in six targets per item.

*Attitudes towards environmental product aspects and innovative product aspects.* Three items assessed the respective behavioural beliefs concerning environmental aspects of the

product (e.g., 'This chair[2] is eco-friendly.') and the related value of the consequence (e.g., 'I evaluate the eco-friendliness of a chair as …'). Again, three items were presented for the behavioural beliefs related to innovative aspects of the product (e.g., 'This chair is creative and fancy.') and the corresponding value of the consequence (e.g., 'I evaluate creativity and fanciness of a chair as …').

*Subjective norm.* The normative beliefs were measured with three items (e.g., 'My household members would like this chair'), just as the motivation to comply (e.g., 'Being consistent with my household members' preference is…').

*Perceived behavioural control.* Four items assessed the control beliefs (e.g., 'Reading product information is essential for evaluating the quality of this chair.') and another four items measured the corresponding personal power (e.g., "I evaluate having to read product information about a chair in order to estimate its quality is …").

*Behavioural intention.* To encounter reliability and validity problems associated with single-item measures, two items assessed the behavioural intention (BI) to purchase the considered product: 'If I wanted to buy chairs, I would take a closer look at this chair' (BI1) and 'If I had to buy a chair today, I would buy this chair' (BI2). While BI1 directly refers to purchase intention, BI2 measures if the product is part of the respondent's evoked set, which comprises those alternatives an individual considers in the purchase decision (Howard, 1963; Howard and Sheth, 1969). BI1 and BI2 were both assessed for each combination of material and appearance. Respondents answered on a 5-point scale, ranging from 1 (disagree) to 5 (agree).

*Choice behaviour.* A CBCA (Green and Rao, 1971) was conducted to receive a proxy variable for respondents' purchase behaviour. The number of choices per participant was reduced by a fractional factorial design. Each participant received 14 choice sets with two alternative products and a no-choice option. Two sets were fixed and 12 were randomly assigned by *Sawtooth Software, Inc. SSI web* (version 8.2). A balanced overlap design was employed owing to its advantages for estimating the main effects and interactions (Chrzan and Orme, 2000). Table 2 documents the three attributes of the CBCA and their levels. While all levels were shown verbally, the description of the 'appearance' levels was supplemented with the photographs introduced in the beginning of the survey. According to Table 2, material correlated with price to reflect current market offers.

**Table 2** Attributes and levels of the CBCA

| *Attributes* | | *Levels* | | |
|---|---|---|---|---|
| Material | | Solid wood | WPC | Plastics |
| Appearance | | Wooden surface | Synthetic surface | |
| Price | *Solid wood* | 60 €[1]/120 €[2]/120 €[3] | 70 €[1]/140 €[2]/150 €[3] | 80 €[1]/160 €[2]/180 €[3] |
| | *WPC* | 50 €[1]/100 €[2]/150 €[3] | 60 €[1]/120 €[2]/180 €[3] | 70 €[1]/140 €[2]/210 €[3] |
| | *Plastics* | 40 €[1]/80 €[2]/180 €[3] | 50 €[1]/100 €[2]/210 €[3] | 60 €[1]/120 €[2]/240 €[3] |

Price levels vary as a function of product category.

[1]Chair, [2]window frame, [3]fence.

### *3.3 Data analyses*

In the first step of data preparation, the comparative belief items were calculated describing the relative expectancy for WPCs. Thereby, the average expectancy over all material and appearance combinations was subtracted from the mean expectancy for both WPC products (i.e., wooden and synthetic surface).

Similarly, the purchase intention was ipsatised (i.e., the average intention over all six product variants was subtracted from the intention to buy a WPC product) to estimate the preference for WPC products in relation to solid wood and full plastics, and to eliminate any acquiescence. The attitude towards environmental product aspects, attitude towards innovative product aspects, subjective norm and PBC products were computed by multiplying each comparative belief item with the corresponding value item, the latter rescaled to −1/+1.

From the CBCA, the resulting individual utility values (part-worth utilities; Green and Rao, 1971) were computed for all attributes. Specifically, the part-worth utility for WPC served as the operationalisation of WPC choice behaviour. Rescaled zero-centred differences were used instead of raw values, as the former eliminate individual scale factor differences.

Data were prepared for subsequent analysis with SPSS 21. The TPB variables were computed and the input correlation matrix for structural equation modelling was generated. Subsequently, the proposed TPB model was tested with LISREL 9.1.

## 4 Results

### *4.1 Descriptive statistics*

Table 3 reports means and standard deviations for the comparative expectancy and value items. WPCs were perceived to be slightly less ecologically beneficial overall, but somewhat more innovative than the mean over all three materials, given a higher ecological image of the solid wood alternative. The perceived WPC preference of relevant others also deviates from the centre position between wood and plastics. Overall, WPCs seem to have fewer factors, which might impede the participant's acceptance compared with the established materials. Both behavioural intention ratings reveal that WPCs were marginally less preferred than the average of all three materials (BI1: $M = -0.08$, $SD = 0.77$, $t = -2.09$, $p = 0.038$; BI2: $M = -0.05$, $SD = 0.67$, $t = -1.30$, $p = 0.194$).

### *4.2 Test of the proposed TPB model*

The test of the proposed TPB model suggests PBC was not a significant determinant for behavioural intention, so this path was eliminated. Even though three items show low factor loadings (SN2, PBC1 and PBC2), they remain in the analyses owing to their conceptual necessity to comprehensively assess the subjective norm and the PBC. Therefore, these loadings are relatively low because of the construct's broadness and the associated low redundancy of its different facets.

The resulting model (Table 4) with 95 degrees of freedom reached a good global fit: the root mean square error of approximation (RMSEA) = 0.048 was below the 0.06 cut-

off (Hooper et al., 2008), and the goodness-of-fit index (GFI) = 0.944, the normed fit index (NFI) = 0.942 and the comparative fit index (CFI) = 0.973 were all above the 0.90 and 0.95 cut-off criteria (Hooper et al., 2008). As PBC was not a predictor of behavioural intention, $H_1$ is only partially supported.

**Table 3** Means and standard deviations of the TPB items

| | *Comparative expectancy component* | | *Value component* | |
|---|---|---|---|---|
| *Item label* | *M* | *SD* | *M* | *SD* |
| *Attitude* (*environmental aspects; AE*) | | | | |
| AE1 | –0.17 | 0.60 | 0.64 | 0.40 |
| AE2 | –0.34 | 0.65 | 0.60 | 0.41 |
| AE3 | –0.01 | 0.70 | 0.63 | 0.39 |
| *Attitude* (*innovative aspects; AI*) | | | | |
| AI1 | 0.00 | 0.54 | 0.42 | 0.45 |
| AI2 | 0.12 | 0.64 | 0.32 | 0.45 |
| AI3 | 0.33 | 0.79 | 0.44 | 0.43 |
| *Subjective Norm* (*SN*) | | | | |
| SN1 | –0.14 | 0.56 | 0.48 | 0.46 |
| SN2 | –0.12 | 0.51 | 0.02 | 0.49 |
| SN3 | –0.16 | 0.57 | 0.53 | 0.44 |
| *Perceived behavioural control* (*PBC*) | | | | |
| PBC1 | –0.11 | 0.55 | –0.43 | 0.47 |
| PBC2 | 0.14 | 0.49 | 0.23 | 0.57 |
| PBC3 | –0.24 | 0.56 | –0.54 | 0.48 |
| PBC4 | –0.40 | 0.58 | –0.31 | 0.63 |

**Table 4** Standardised path coefficients and significance levels of the measurement model

| *Parameter estimate* | *Standardised* | *SE* | *p-value* |
|---|---|---|---|
| Attitude (environmental aspects) → AE1 | 0.74 | 0.05 | 0.001 |
| Attitude (environmental aspects) → AE2 | 0.45 | 0.06 | 0.001 |
| Attitude (environmental aspects) → AE3 | 0.75 | 0.05 | 0.001 |
| Attitude (innovative aspects) → AI1 | 0.67 | 0.06 | 0.001 |
| Attitude (innovative aspects) → AI2 | 0.50 | 0.06 | 0.001 |
| Attitude (innovative aspects) → AI3 | 0.67 | 0.06 | 0.001 |
| Subjective norm → SN1 | 0.87 | 0.05 | 0.001 |
| Subjective norm → SN2 | 0.23 | 0.06 | 0.001 |
| Subjective norm → SN3 | 0.80 | 0.05 | 0.001 |

**Table 4** Standardised path coefficients and significance levels of the measurement model (continued)

| *Parameter estimate* | *Standardised* | *SE* | *p-value* |
|---|---|---|---|
| PBC → PBC1 | 0.24 | 0.07 | 0.001 |
| PBC → PBC2 | 0.20 | 0.07 | 0.005 |
| PBC → PBC3 | 0.63 | 0.09 | 0.001 |
| PBC → PBC4 | 0.55 | 0.08 | 0.001 |
| Behavioural intention → BI1 | 0.85 | 0.02 | 0.001 |
| Behavioural intention → BI2 | 0.84 | 0.04 | 0.001 |

Table 5 shows the correlation matrix between the latent variables. The correlations suggest that increases in attitude (environmental aspects as well as innovative aspects) and subjective norm are accompanied by a higher behavioural intention. Subjective norm shows the highest correlation with behavioural intention, whereas PBC only reached a small correlation. The drivers of behavioural intention correlate similarly with choice behaviour. The high correlation between behavioural intention and choice behaviour is in line with TPB assumptions.

**Table 5** Correlation matrix of the latent variables

| *Latent construct* | | *1* | *2* | *3* | *4* | *5* | *6* |
|---|---|---|---|---|---|---|---|
| 1 | Attitude (environmental aspects) | 1.00 | | | | | |
| 2 | Attitude (innovative aspects) | 0.62 | 1.00 | | | | |
| 3 | Subjective norm | 0.47 | 0.59 | 1.00 | | | |
| 4 | Perceived behavioural control | 0.33 | 0.34 | 0.18 | 1.00 | | |
| 5 | Behavioural intention | 0.58 | 0.60 | 0.70 | 0.22 | 1.00 | |
| 6 | Choice behaviour | 0.35 | 0.39 | 0.43 | 0.26 | 0.61 | 1.00 |

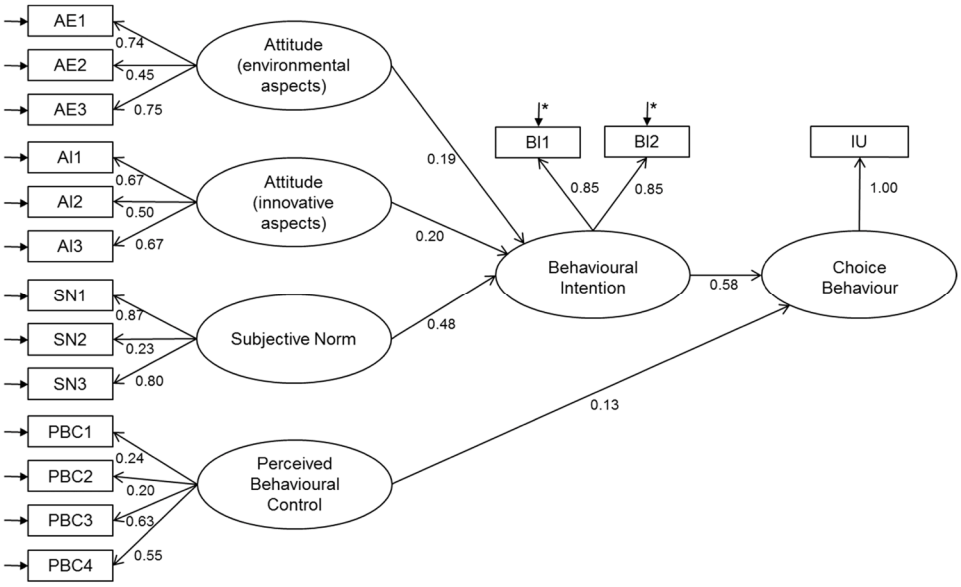
Table 6 presents the parameter estimates of the structural model. Attitude towards environmental product aspects ($\beta = 0.19$), attitude towards innovative product aspects ($\beta = 0.20$) and subjective norm ($\beta = 0.48$) explained 56% of the variance in behavioural intention. Both behavioural intention ($\beta = 0.58$) and PBC ($\beta = 0.13$, $t = 2.13$) predicted an individual's choice behaviour ($R^2 = 0.39$).

**Table 6** Standardised path coefficients and significance levels of the structural model

| *Parameter estimate* | *Standardised* | *SE* | *p-value* |
|---|---|---|---|
| Attitude (environmental aspects) → Behavioural intention | 0.19 | 0.08 | 0.022 |
| Attitude (innovative aspects) → Behavioural intention | 0.20 | 0.09 | 0.022 |
| Subjective norm → Behavioural intention | 0.48 | 0.07 | 0.001 |
| Behavioural intention → Choice behaviour | 0.58 | 0.05 | 0.001 |
| PBC → Choice behaviour | 0.13 | 0.06 | 0.033 |

To sum up, the proposed TPB model was supported with the exception of a direct influence of PBC on behavioural intention (Figure 2). Hence, $H_2$ and $H_3$ are confirmed.

**Figure 2** The final TPB model




AE = Attitude (environmental aspects), AI = Attitude (innovative aspects), SN = Subjective Norm, PBC = Perceived Behavioural Control, BI = Behavioural Intention, IU = Individual Utility Values from the CBCA.

AE, AI, SN and PBC items represent the product of the comparative expectancies with the value component.

*The Error Variances of BI1 and BI2 were set equal and of IU were set equal zero to allow identification.

## 5 Discussion

WPCs are innovative and eco-friendly materials as they are a novel approach to optimise resource efficiency of the production in the timber industry. However, owing to the novelty of these materials, there is a lack of research concerning consumer acceptance of WPC products and especially their antecedents. This work builds on the TPB (Ajzen, 1991), which has successfully predicted various instances of eco-friendly consumer behaviour (e.g., Donald et al., 2014; Read et al., 2013; Vermeir and Verbeke, 2008; Wan et al., 2014). Therefore, a theoretical framework based on the TPB is used to identify important drivers of consumer acceptance of WPC products. To generalise WPC acceptance across diverse fields of application, different product categories (i.e., chair, window frame and fence) are included in the online survey.

Overall, the results of this study demonstrate the utility of the TPB as a framework for identifying the drivers of consumers' intention to buy WPC products and their choice behaviour. According to Henard and Szymanski (2001), the differentiation from conventional alternatives is an important aspect. The results of this study imply that

respondents, who perceived the advantages of WPCs and valued the benefits, intended to buy WPC products and chose them more frequently. Specifically, attitude towards environmental product aspects, attitude towards innovative product aspects and the subjective norm emerged as significant predictors of the behavioural intention. The path coefficients revealed that the subjective norm has the strongest influence maybe because all three product categories are used at home and are the target of family decisions, therefore leading to strong social pressure. Attitude towards environmental product aspects and attitude towards innovative product aspects are of equal importance. These findings support the previously stated importance of innovativeness in relation to eco-friendly consumption (Englis and Phillips, 2013). Contrary to TPB assumptions, PBC did not significantly affect the behavioural intention. The centrality of the subjective norm and the insignificance of other paths are also shown in studies predicting the acceptance of alternative energy (Read et al., 2013) and wood products (Kalafatis et al., 1999) as well as the choice of an eco-friendly restaurant (Kim et al., 2013) where the subjective norm was the most important determinant of the behavioural intention. The behavioural intention ratings assessing WPC acceptance in relation to solid wood and full plastics showed that consumers' intention to buy WPC products is, if at all, only slightly below the intention averaged across all three materials. Therefore, these results are in line with current research suggesting that consumers' choices for WPC products are just in between products consisting of solid wood and full plastics (Osburg et al., 2014, 2015b). Finally, this study shows that while PBC was not a significant predictor of the behavioural intention, this component had an influence on consumers' choice behaviour in addition to the behavioural intention. According to the assumptions of Ajzen (1991), PBC seemed to be a good proxy of the actual control with high PBC facilitating behaviour execution.

This study reveals several implications for the marketing of WPC products. First, the strong influence of the subjective norm strengthens the necessity to promote WPCs as a social trend. This finding is in line with the previous research showing that the social circle can lead to more environmentally friendly consumption patterns (Harries et al., 2013). Therefore, marketing should address not only individual consumers, but also their social circle. It should be highlighted that WPC products are beneficial for an individual's significant others. The need to present WPCs as socially acceptable materials is supported by the descriptive statistics. These show respondents expected that their significant others' preferences for WPCs deviate slightly downwards from an intermediate position. Second, the significance of both attitude components implies that marketing should additionally promote an eco-friendly and innovative image of WPCs. An innovative image could be fostered by accentuating the novel combination of wood and plastic components, leading to materials with additional value compared with established materials (e.g., nearly free, three-dimensional formability). The importance of an eco-friendly WPC image is suggested by the value consumers ascribed to all items, referring to environmental product aspects. The creation of the image is dependent on both the field of application and the question of whether WPCs should substitute plastics or solid wood in the specific case. In general, an eco-friendly image could be enforced if consumers are informed that WPCs are less resource-consuming materials by taking the cascade utilisation into account. As fossil-fuel-based plastics are typically perceived as environmentally hazardous, an eco-friendly WPC image should be easy to communicate. In comparison with solid wood, the environmental benefits resulting from a material utilisation of wood by-products should be highlighted as well as the usefulness of WPCs

for applications where sensitive resources like tropical timber are commonly used. However, marketing must account for the possible risk of consumers associating the utilisation of by-products with a minor quality, as it has been shown for higher-priced products consisting of recycled materials (Achabou and Dekhili, 2013; Davies et al., 2012). Therefore, a proof of the material quality is recommendable, e.g., taking recourse to certification systems. The descriptive statistics indicate another topic for the marketing of these materials by showing that consumers especially question the recyclability of WPCs. As current studies suppose that a WPC is recyclable at the end of the product's life cycle (Beg and Pickering, 2008a, 2008b; Petchwattana et al., 2012; Shahi et al., 2012), this information should be conveyed to potential customers. Third, the results indicate that consumers notice fewer factors impeding a purchase for WPC products in comparison with the mean of the established alternatives. The only potential barrier consumers perceive to be more present is the necessity to deal with product information, which might be attributable to the novelty of WPCs. Hence, marketing should provide consumers with more information about WPCs, while potential customers should be reinforced that WPCs have a good price-performance ratio by drawing attention to the benefits of WPCs consumers already acknowledge (i.e., low consequential costs and maintenance of the product). The recommendation to inform consumers is supported by the fact that most of the respondents were not familiar with WPCs.

To summarise managerial implications, the previous considerations can be classified into the green marketing mix. Referring to the *product*, WPCs are an opportunity to fulfil consumers' demand for eco-friendly and resource-efficient materials. Furthermore, WPCs can increase the product line's depth by addressing consumers' growing environmental concerns. Besides environmental benefits, it should be shown that eco-innovative materials can compete with established ones. This falls within the scope of the *promotion*, which should primarily foster a green and innovative WPC image by considering the consumer's social circle. Nevertheless, the product's quality has to be assured simultaneously, so that much information has to be delivered to consumers. Osburg et al. (2015a) suggest a traceability-system-based provision of detailed wood-product information as a strategy to supply consumers with information items at the Point of Sale (e.g., information about origin and environmental impact). This approach may also be useful for WPCs. This work shows that WPCs often require higher *prices* compared with plastic products. Hence, the surcharge must be explained to consumers by also referring to individual benefits (e.g., low consequential costs and maintenance of the product). Additionally, environmentally concerned and innovative consumers should be addressed in particular, as they are important target groups for the marketing of WPC products (Osburg et al., 2015b) and may therefore be willing to pay a surcharge. In connection with the *place*, this research and previous studies (e.g., Osburg et al., 2014, 2015b) show that WPC products are not only interesting for environmentally concerned and for innovative consumers, though both of them accept these eco-innovative materials, but these products may also have a market for the average consumer. Hence, WPC products no longer represent a market niche, but they are also becoming attractive for the main market.

Furthermore, this study contributes to research about eco-friendly consumer behaviour. Osburg et al. (2014, 2015b) emphasise the importance of evaluating the market success of environmentally sound and innovative products in relation to their most important competitors. This study addresses this claim in a TPB framework. While the TPB is an established theory, which has already been applied to investigate eco-

friendly consumption, this study illustrates how competing consumer behaviour can be evaluated based on a TPB approach by testing all TPB components as comparative scores. Additionally, this study addresses a challenge of TPB studies by considering that consumers' actual behaviour is often difficult to assess. While final purchase decisions could not be determined in this research, using individual utility values of a CBCA is chosen as a method to receive a proxy for respondents' purchase behaviour.

Nevertheless, this study has some limitations, which provide suggestions for future research. Obviously, TPB studies typically rely on self-reported measures, which might show biases such as overestimation. Similarly, the individual utility values of the CBCA as a proxy variable of the consumer behaviour may be limited. As choice behaviour only approaches actual purchase decisions, future research should try to measure real consumer behaviour (e.g., by relying on market data). However, this approach tries to cope with one aspect of the validity problem by the mandatory comparison of beliefs and intentions between all three competing materials. Hence, the acquiescence often responsible for overestimation bias was eliminated.

Subsequent studies should also broaden the spectrum of the compared materials. WPCs indeed mostly compete against solid wood and full plastics. However, for some fields of application, WPCs should be compared with additional materials (such as stone as a popular decking material besides solid wood). In this context, it has to be regarded as well that the current study considers full plastics as an environmentally hazardous material. This definitely applies to the majority of plastics used, which are based on fossil fuels. As the plastics industry increasingly realises the necessity to use an alternative raw material base, plastic manufacturers start to replace conventional plastics with bioplastics. Hence, consumer acceptance of WPCs should also be examined in comparison with more eco-friendly plastic variants. Additionally, subsequent studies should address the generalisability of the present findings for other markets where WPCs are more or less common than in Germany. Overall, this study could present an interesting framework for future research investigating consumer acceptance of new materials or products, which are based on a combination of established ones.

## 6 Conclusions

In summary, the continuously growing global resource demand and various environmental problems require a development of resource-efficient materials. WPCs are promising eco-innovative materials as they mainly consist of wood by-products, which are otherwise used for energy purposes. However, the market success of WPC products depends on consumers. This study, which is built on a TPB framework, helps to understand the determinants of consumer acceptance. Thereby, the subjective norm emerges as an important driver of the purchase intention, just as do attitudes towards environmental and innovative product aspects. Therefore, marketing should use these findings as a starting point for developing strategies to further increase WPC acceptance and to contribute to the realisation of a more sustainable consumption.

## Acknowledgement

This research was supported by the German Research Foundation (DFG), grant GRK 1703/1 for the Research Training Group "Resource Efficiency in Interorganisational Networks – Planning Methods to Utilise Renewable Resources".

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## Notes

[1]The properties discussed here and performances of WPCs are a selection of parameters, which should be examined when comparing WPCs with the established materials. However, the listing has to be considered carefully as the specification of the advantages depends on the definite WPC composition (Caufield *et al.*, 2005). For a detailed overview of WPC contribution to efficient resource utilisation and its dependency on WPC composition, see Teuber *et al.* (2015).

[2]Depending on the assigned condition, 'chair' was replaced by either 'window frame' or 'fence'. This applies to all the following item examples.

## Appendix

**Appendix A** Characteristics of respondents

| *Variable* | | *Number of respondents* |
|---|---|---|
| Gender | Male | 164 |
| | Female | 193 |
| Profession | Student | 34 |
| | Employee | 111 |
| | Executive employee | 29 |
| | Freelancer | 34 |
| | Executive | 22 |
| | Housewife/-husband | 20 |
| | Retiree | 91 |
| | Unemployed | 14 |
| | Others | 2 |

**Appendix A** Characteristics of respondents (continued)

| *Variable* | | *Number of respondents* |
|---|---|---|
| Household size | 1 | 79 |
| | 2 | 151 |
| | 3 | 65 |
| | 4 | 45 |
| | 5 | 12 |
| | >5 | 5 |
| Monthly household income | <500 € | 5 |
| | 500–999 € | 29 |
| | 10001999 € | 101 |
| | 2000–2999 € | 114 |
| | 3000–3999 € | 67 |
| | 4000–4999 € | 24 |
| | 5000–5999 € | 10 |
| | >6000 € | 7 |
| WPC knowledge | Unknown | 212 |
| | known from hearsay | 133 |
| | well known | 12 |
| Total number of respondents | | 357 |

**Appendix B** The TPB items, their labels and references

| *Label* | *Item* | *References* |
|---|---|---|
| Attitude (environmental aspects; AE) | | |
| AE1 | Eco-friendly product | Carus et al. (2008), Eder and Carus (2013), Groot and Steg (2007), Han et al. (2010), Jonsson et al. (2008), Pritchard (2004), Sparks and Shepherd (1992), Thompson et al. (2010), Vogt et al. (2006), Weinfurter and Eder (2009) |
| AE2 | Recyclable product | Beg and Pickering (2008a, 2008b), Petchwattana et al. (2012), Pritchard (2004), Shahi et al. (2012), Vogt et al. (2006), Weinfurter and Eder (2009) |
| AE3 | Sustainable and resource efficient product | Bumgardner and Bowe (2002), Carus et al. (2008), Pakarinen and Asikainen (2001), Thompson et al. (2010), Vogt et al. (2006) |
| Attitude (innovative aspects; AI) | | |
| AI1 | Creative and original product | Henard and Szymanski (2001), Horn and Salvendy (2006), Weinfurter and Eder (2009 |
| AI2 | Exceptional product | Bumgardner and Bowe (2002), Caufield et al. (2005), Pritchard (2004), Weinfurter and Eder (2009) |
| AI3 | Innovative product | Bumgardner and Bowe (2002), Caufield et al. (2005), Weinfurter and Eder (2009) |

**Appendix B** The TPB items, their labels and references (continued)

| *Label* | *Item* | *References* |
|---|---|---|
| Subjective norm (SN) | | |
| SN1 | Family | Groot and Steg (2007), Han et al. (2010), Sparks and Shepherd (1992), Taylor and Todd (1995), Vermeir and Verbeke (2008) |
| SN2 | Friends | Groot and Steg (2007), Han et al. (2010), Sparks and Shepherd (1992), Taylor and Todd (1995), Vermeir and Verbeke (2008) |
| SN3 | Household members | Ewing (2001), Reid et al. (2010), Taylor and Todd (1995) |
| Perceived behavioural control (PBC) | | |
| PBC1 | Expensive product | Carus et al. (2008), Caufield et al. (2005), Haider and Eder (2010), Pakarinen and Asikainen (2001), Weinfurter and Eder (2009) |
| PBC2 | Need of explanation | Eder and Haider (2011), Pakarinen and Asikainen (2001) and Vogt et al. (2006) |
| PBC3 | Consequential costs | Pritchard (2004), Suttie (2007), Thompson et al. (2010), Weinfurter and Eder (2009) |
| PBC4 | Maintenance of the product | Bumgardner and Bowe (2002), Caufield et al. (2005), Eder and Haider (2011), Pritchard (2004), Vogt et al. (2006), Suttie (2007), Weinfurter and Eder (2009) |