Heterogeneous Good

Foundations • The Valuation Engineer

Bert Craytor• July 9, 2026
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Formal definition. Heterogeneous goods are goods that are not interchangeable because each is a distinct bundle of characteristics that buyers value separately, and whose characteristics are not separately traded.

Intuitive framing. A homogeneous good is one where any item will do: a barrel of WTI crude, a bushel of No. 2 yellow corn, a kilowatt-hour from the grid, a share of a given stock. The grading standards or specifications behind these goods exist precisely to make individual items interchangeable, so that prices apply to the category rather than to the particular item. A heterogeneous good is one where the specific item matters — *this* house, not *that* house; *this* used car, not the one next to it.

Two features make a good heterogeneous in the technical sense. First, buyers care about multiple distinguishable attributes that vary across items in the market. Second, those attributes are bundled by the production technology of the good; they are not separately purchasable. You cannot buy 200 square feet of gross living area on its own. You cannot acquire a school district independently of a parcel of land. The characteristics arrive bundled, and the market sets a price on whole bundles rather than on the characteristics themselves.

Real estate is the canonical heterogeneous good and exhibits the property unusually strongly. Locational characteristics are perfectly non-replicable: no two parcels can occupy the same location, so every property has at least one attribute (its coordinates) that distinguishes it from every other property in the market. Physical, legal, and environmental attributes layer additional dimensions of variation onto a vector that, taken as a whole, is unique to each property.

Where appraisers encounter it. Every adjustment in the sales comparison approach is an implicit acknowledgment that the subject and the comparables are heterogeneous goods. If properties were homogeneous, sale prices would already be directly comparable; no grid would be needed. The grid is an attempt to reconcile the prices of distinct bundles by adjusting for differences in the bundle composition. It is worth noting what the grid does *not* do: it never decomposes a sale price into feature value contributions. The traditional grid has no column for value contributions — only adjustments, estimated directly, feature by feature.

The cost approach handles heterogeneity by reconstructing the bundle from its components — foundation, framing, finishes, depreciation — and pricing each separately. The income approach handles it by abstracting the bundle into a single cash-flow profile, with capitalization and yield rates absorbing bundle-level heterogeneity into a market-derived multiplier. All three valuation approaches are methodological responses to the underlying fact that real estate is a heterogeneous good. They differ in how they navigate that fact, not in whether they confront it.

Appraisers also encounter heterogeneity informally whenever they reason about comp selection, paired-sales analysis, or "apples-to-apples" comparisons. The instinct to find comparables that are similar in as many attributes as possible is a practitioner's response to heterogeneity: minimize the bundle distance between subject and comp, and the unobserved component of the bundle contributes less to the difference in sale prices.

Why it matters for defensibility. The heterogeneity of real estate is the reason valuation methodology must exist as a discipline. If properties were interchangeable, market value would be directly observable from posted prices; valuation would reduce to lookup. Because they are not, value must be inferred from the prices of related-but-not-identical properties, and every inference step is a methodological choice that has to be justified.

Acknowledging heterogeneity formally clarifies several practice questions that USPAP and Standards Rule defensibility hinge on. Comp selection is the choice of items in characteristics space close enough to the subject that the implicit prices recovered from them generalize. The reasonableness of an adjustment depends on whether the underlying implicit price is supportable from market evidence. The reconciliation between approaches reflects the appraiser's judgment about which approach navigates the heterogeneity of *this* property most credibly. Each of these defensibility questions is sharper once "heterogeneous good" is named as the underlying condition.

Worked appraisal example. Two recent sales in the same Pacifica, California neighborhood:

Attribute	Comp A	Comp B
GLA (sf)	1,650	1,650
Bedrooms / Baths	3 / 2	3 / 2
Lot (sf)	9,000	7,200
View	Yes	No
Sale price	$1,425,000	$1,280,000

Under a homogeneous-goods framing, these are the same property: identical GLA, identical room count, same neighborhood. Under the heterogeneous-goods framing, they are distinct bundles, differing in two characteristics (lot and view) that buyers value separately. The $145,000 price difference is the *joint* contribution of those two attributes — two implicit prices entangled in a single pair.

Recovering the implicit prices individually requires more pairs, ideally varying one attribute at a time. Three or four additional sales spanning the view/no-view and large-lot/small-lot combinations begin to identify the implicit prices separately. With enough variation across enough comps, hedonic regression performs the disentanglement formally; with limited variation, the appraiser is constrained to bracketed paired-sales reasoning whose reliability depends explicitly on how close the bundles are to one another in characteristics space.

The example illustrates why heterogeneity is the root condition: even two "identical" houses are not identical, and the methodological apparatus of appraisal exists precisely to handle the distance between them.

References.

Lancaster, K. J. (1966). A New Approach to Consumer Theory. *Journal of Political Economy*, 74(2), 132–157.

Rosen, S. (1974). Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economy*, 82(1), 34–55.

Cross-references: characteristics space; *hedonic price function*; *implicit price.*

Addendum: Prolog Formalization

The following machine-readable companion (`001-heterogeneous-good.pl`) formalizes this entry in the journal's Prolog knowledge base. It is also published as a browsable galley alongside this article.

```
%% 001-heterogeneous-good.pl
%%
%% Prolog companion to Foundations Vol. 1, Issue 1, Article 001
%%   Title:    Heterogeneous Good
%%   Author:   Bert Craytor
%%   Concept:  heterogeneous_good
%%   Version:  0.1.0-draft
%%
%% This file is the Prolog galley for the article: it encodes the
%% article's main claims, worked example, and inference rules in a form
%% that other Prolog code in the journal can consult, query, and verify
%% against. Read alongside the entry.tex / entry.pdf prose.

% ====================================================================
% DICTIONARY IMPORT
% ====================================================================
%
% The journal-wide dictionary is the source of truth for term definitions
% and relation schemas. The use_module below pulls those facts in at
% runtime; the comments that follow reproduce the relevant entries so a
% reader skimming this file in isolation can see what's been imported.

:- use_module('../../../../tools/dictionary/dictionary').
:- dictionary_release('dictionary-2026.1').

% --- From the dictionary (loaded via :- use_module above) -----------
% term(heterogeneous_good, "Heterogeneous Good", economic_theory,
%      "Heterogeneous goods are goods that are not interchangeable
%       because each is a distinct bundle of characteristics that buyers
%       value separately, and whose characteristics are not separately
%       traded.", published, 'dictionary-2026.1').
%
% term(characteristics_space, "Characteristics Space", economic_theory,
%      "The characteristics space of a class of heterogeneous goods is
%       the vector space whose coordinates index the attributes that
%       buyers value, and in which each good is represented by the
%       vector of its attribute levels.", published, 'dictionary-2026.1').
%
% term(implicit_price, "Implicit Price", economic_theory,
%      "The implicit price of a characteristic is the partial derivative
%       of the hedonic price function with respect to that characteristic,
%       evaluated at a point in the characteristics space; it represents
%       the marginal market price of an incremental unit of the
%       characteristic, holding all other characteristics fixed.",
%      published, 'dictionary-2026.1').
%
% term(hedonic_price_function, ...).
%
% relation(depends_on, 2, "depends on", [foundations_concept, foundations_concept],
%          foundations_methodology, "...", accepted, 'dictionary-2026.1').
% relation(related, 2, ...).
%
% These facts are NOT declared in this file; the use_module above is
% what makes them available at runtime.
% --------------------------------------------------------------------
```

```
:- use_terms([ % Foundations concepts (terms/foundations.pl)
               heterogeneous_good, characteristics_space, implicit_price,
               hedonic_price_function,
               % Practice terms (terms/valuation-practice.pl)
               real_estate, homogeneous_good,
               sales_comparison_approach, cost_approach, income_approach,
               comp_selection, paired_sales_analysis, adjustment,
               reconciliation, uspap, standards_rule ]).
:- use_relations([related/2, depends_on/2]).

% ========================================================================
% ARTICLE SUBJECT
% ========================================================================

article_concept(heterogeneous_good).
article_issue(volume(1), number(1), year(2026)).
article_id('foundations.2026.001').

% ========================================================================
% ARTICLE-LOCAL VOCABULARY
% ========================================================================
%
% Terms the article needs that are NOT yet in the dictionary, and that
% the editor decided are too narrow to promote. These are field names
% for the worked-example property records | not concepts in the
% journal's ontology.

local_term(gla_sqft).
local_term(bedrooms).
local_term(baths).
local_term(lot_sqft).
local_term(view).

% ========================================================================
% FORMAL DEFINITION (restated as Prolog rule)
% ========================================================================
%
% From the formal definition: a good is heterogeneous IF buyers care
% about multiple distinguishable attributes that vary across items in
% the market, AND those attributes are bundled by production rather
% than separately traded.

%! heterogeneous(?Good) is nondet.
%
% True when Good satisfies both bundling criteria. The two predicates
% buyers_value_multiple_attributes/1 and attributes_bundled_by_production/1
% must be asserted for specific goods elsewhere; here they characterize
% the formal definition itself.

heterogeneous(Good) :-
    buyers_value_multiple_attributes(Good),
    attributes_bundled_by_production(Good).

% ========================================================================
% INTUITIVE FRAMING | CONTRASTS WITH HOMOGENEOUS GOODS
% ========================================================================

% Canonical examples of homogeneous goods cited in the article.
canonical_homogeneous_example(wti_crude).
```

```
canonical_homogeneous_example(no_2_yellow_corn).
canonical_homogeneous_example(kilowatt_hour).
canonical_homogeneous_example(common_stock_share).

% Their distinguishing feature: grading or specification standards make
% individual items interchangeable.
interchangeable_via_grading(wti_crude).
interchangeable_via_grading(no_2_yellow_corn).
interchangeable_via_specification(kilowatt_hour).
interchangeable_via_specification(common_stock_share).

% Canonical heterogeneous goods.
canonical_heterogeneous_example(real_estate).
canonical_heterogeneous_example(used_car).
canonical_heterogeneous_example(unique_machinery).

% Why real estate exhibits heterogeneity unusually strongly:
% locational characteristics are perfectly non-replicable.
buyers_value_multiple_attributes(real_estate).
attributes_bundled_by_production(real_estate).
non_replicable_attribute(real_estate, location).

% ======================================================================
% APPRAISER ENCOUNTERS
% ======================================================================
%
% The three classical valuation approaches are all methodological
% responses to heterogeneity. They differ in HOW they navigate the
% bundle, not in WHETHER they confront it.

valuation_approach(sales_comparison_approach).
valuation_approach(cost_approach).
valuation_approach(income_approach).

responds_to_heterogeneity(sales_comparison_approach,
    "Reconciles the prices of distinct bundles by adjusting for composition differences; the grid
    ↪records only adjustments, estimated directly, and never decomposes a price into feature value
    ↪ contributions.").
responds_to_heterogeneity(cost_approach,
    "Reconstructs the bundle from priced components: foundation, framing, finishes, depreciation.").
    ↪
responds_to_heterogeneity(income_approach,
    "Abstracts the bundle into a single cash-flow profile; cap/yield rates absorb heterogeneity.").

% Practitioner-level encounters with heterogeneity.
practitioner_response_to_heterogeneity(comp_selection,
    "Minimize bundle distance between subject and comp in characteristics space.").
practitioner_response_to_heterogeneity(paired_sales_analysis,
    "Isolate an attribute's contribution by holding other attributes constant.").
practitioner_response_to_heterogeneity(adjustment,
    "Quantify the price impact of one differing attribute at a time.").

% ======================================================================
% DEFENSIBILITY
% ======================================================================
%
% Why naming "heterogeneous good" sharpens USPAP defensibility questions.

defensibility_consequence(comp_selection,
```

```
    "Comps must be close enough in characteristics space that recovered implicit prices generalize
   ↪ .").
defensibility_consequence(adjustment,
    "Each adjustment must be supportable from market evidence of the implicit price.").
defensibility_consequence(reconciliation,
    "Choice among approaches reflects which best navigates THIS property's heterogeneity.").

% Root claim: valuation methodology exists as a discipline BECAUSE
% real estate is heterogeneous. If it were homogeneous, value would be
% directly observable from posted prices.
root_claim(
    "Valuation methodology exists as a discipline because real estate is heterogeneous; in the
   ↪ homogeneous case, value would be directly observable.").

% ======================================================================
% WORKED EXAMPLE | PACIFICA COMPS
% ======================================================================
%
% Two recent sales in the same Pacifica, California neighborhood. The
% example demonstrates that even "identical" houses are not identical:
% the $145,000 price spread is the joint contribution of differences in
% lot size and view, two implicit prices entangled in a single pair.

% The 8-comp Pacifica dataset is shared across entries 001-006 and
% lives in kb/pacifica_comps.pl. Consulting it here brings property/1,
% in_market/2, attribute_value/3, and sale_price/2 into this article's
% namespace.
:- consult('../../kb/pacifica_comps').

% --- Derived facts from the example -------------------------------

% The attributes that differ between the two comps.
differing_attribute(comp_a, comp_b, lot_sqft).
differing_attribute(comp_a, comp_b, view).

% The price differential and what it's attributable to.
price_differential(comp_a, comp_b, 145000).
attributed_to(price_differential(comp_a, comp_b, 145000),
              [implicit_price_of(lot_sqft), implicit_price_of(view)]).

% --- Article's argument about identification ----------------------

% A single pair cannot separately identify the two implicit prices |
% they are entangled in the single $145K observation.
joint_identification_only(price_differential(comp_a, comp_b, 145000),
                          [lot_sqft, view]).

% Separate identification requires more pairs varying one attribute at
% a time. With sufficient variation, hedonic regression performs the
% disentanglement formally; with limited variation, the appraiser uses
% bracketed paired-sales reasoning, whose reliability depends on how
% close the bundles are in characteristics space.
identification_strategy(few_pairs,
    "Bracketed paired-sales reasoning. Reliability depends on bundle proximity in characteristics
   ↪ space.").
identification_strategy(many_pairs_with_variation,
    "Hedonic regression (see hedonic_regression).").

% ======================================================================
```

```
% INFERENCE RULES
% ========================================================================

%! comparable(?A, ?B) is nondet.
%
% A and B are comparable when they are distinct properties in the same
% market. This is the operational definition of "comp" used implicitly
% in the article.

comparable(A, B) :-
    property(A),
    property(B),
    A \== B,
    in_market(A, M),
    in_market(B, M).

%! attribute_difference(?A, ?B, ?Attr, ?DA, ?DB) is nondet.
%
% A and B differ on Attr, with DA the value at A and DB the value at B.
% Use this to enumerate the dimensions on which two comps actually vary.

attribute_difference(A, B, Attr, DA, DB) :-
    comparable(A, B),
    attribute_value(A, Attr, DA),
    attribute_value(B, Attr, DB),
    DA \== DB.

%! identifiable_implicit_price(?Attr) is nondet.
%
% An attribute's implicit price is identifiable from the observed comps
% if there exists at least one pair of comparables differing ONLY in
% that attribute. With our two-comp example this fails for lot_sqft AND
% view (both differ in the same pair), which is exactly the article's
% point.

identifiable_implicit_price(Attr) :-
    comparable(A, B),
    findall(X, attribute_difference(A, B, X, _, _), Diffs),
    Diffs == [Attr].

% ========================================================================
% CROSS-REFERENCES
% ========================================================================
%
% Concepts the article cross-references (corresponding to the
% \foundationsref{} macros in entry.tex).

cross_reference(characteristics_space).
cross_reference(hedonic_price_function).
cross_reference(implicit_price).
```