



Economic Accounting in the Simple Hotelling Model[☆]



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ABSTRACT

Because of its simplicity, the simple Hotelling model of exhaustible-resource extraction is a useful vehicle to address two themes in economic accounting: (1) Foundational equalities in the calculation of depreciation and in double-entry bookkeeping, or circular flow, apply in both accounting and economics. (2) Incentives, decisions and outcomes are crucial in economics. It is argued that financial accounting satisfies the demands of the first theme but not the second and that green accounting falls short on both. Both can be satisfied if capital gains are included in net income and product. Comparisons are made to studies in general economics.

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1. Introduction: resource accounting on a two-way street

A finding of the analysis of green accounting for an exhaustible resource in the simple Hotelling model is that, if marginal extraction cost is constant, the depreciation of the reserve at any time is equal to the net value of output. Contrary to financial (corporate) accounting, which makes no provision for depreciation of the reserve, green accounting holds that in this central case the resource makes no contribution to the net income of a firm, sector or nation, but that the value of sales is the realization of value embodied in the resource.

The Hotelling model holds that resources are a form of capital. Returns to manufactured capital contribute to its owners' and to national net income. Like manufactured capital, resource capital is used up in production and is valued according to its contribution to social well-being. In green accounting, however, resource capital is subject to different accounting rules. Asheim and Hartwick (2011: 2303) consider it an "anomaly that no entry for natural capital appears on the income side of the accounts".

Accounting organizes raw data for use in empirical analysis and further theoretic development. Its aim is to provide a conceptual and numeric rendering of decisions and their consequences. For centuries financial accounting has been a highly successful economic institution for recording and interpreting commercial transactions. Yet green accountants find that it goes wrong in a model with no market failure and optimal decisions.

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The present paper examines the economics of accounting in the simple Hotelling model. In the model, a known, homogeneous reserve is exploited in continuous time by symmetric, competitive sellers under conditions of constant returns to scale, stationary demand and perfect knowledge. There is no exploration or development; at an initial time $t=0$ a stock $S(0) = S_0$ is simply held by the owners. Extraction cost is zero. The stock of the resource earns capital gains consistently with Hotelling's rule that price rises at the rate of interest.

Gaudet (2007) identifies several ways in which the model is not an accurate portrayal of resource exploitation. It abstracts from exploration, development, the locations of different deposits, the physical and chemical properties of the resource, realistic technology and geology, and uncertainty. Furthermore, the use of sunk capital in producing the resource leads to a fundamental problem of accounting (Cairns, 2009, 2013; see also El Serafy, 1989 for early insights). The conclusion that net income is zero does not survive many of these extensions. In most, however, the Hotelling rent is considered to measure depreciation.

There are good reasons for studying this unrepresentative model. (1) Widely recognized as the foundation of resource economics, it is being applied in green accounting for various non-renewable resources. An economically accurate perception of income is essential to assess the performance of resource-producing firms and economies, as well as to formulate taxes and other policies. (2) With no sunk capital, the fundamental problem does not arise. There are no complications from other assets or from nonlinearity. Moreover, in the model, the distinction between capital-stock and commodity-flow approaches (Wei 2013) is moot. (3) A scooter on what Heal (2007: 7) calls a two-way street between resource economics and broader economics, the model is of particular interest because Hotelling (1925) also wrote on accounting for depreciation. While it is oversimplified, its specific analytic results render an intricate discussion of the following issues more manageable.

- A Accounting can be for wealth, defined as the present value of consumption, or welfare, frequently defined as the present value of the utility of consumption.
- B Hicks (1946) enunciated three concepts of income. Income no. 1 refers to maintaining present value in the short term, nos. 2 and 3 to sustaining current value in the long term.
- C The contributions of a given resource sector and of its firms must be addressed.
- D The relationship of accounting for the resource and for other assets has to be clarified.
- E Accounting can be in terms of real or present-value prices.
- F Double-entry bookkeeping plays a lead role in accounting and, in the guise of circular flow, in economics. Resulting accounting identities are central.

The following accounting equalities apply to the present value of net benefits, denoted by V .

E1, Adding Up. *The undiscounted sum of depreciation is equal to value.*

Depreciation in period $t + 1$ is $V_t - V_{t+1}$. If $\lim_{t \rightarrow \infty} V_t = 0$ then $V_0 = \sum_{t=0}^{\infty} (V_t - V_{t+1})$.

E2, Balance. *Net income and product are equal.*

In economics, E2 expresses the circular flow; in accounting, it is a double-entry condition.

A main message of the model is that capital gains have allocational significance. From a study of issues A through F, in the context of equalities E1 and E2, the present paper concludes that the resource should be considered to earn an income in the form of capital gains. It explains that not including capital gains in income can be consistent with double-entry bookkeeping (with the circular flow) but that it neglects aspects of decisions that are critical to an economic assessment. Divergences from financial and green accounting are the imputation of (a) a strictly positive net income in the form of capital gains as the resource price evolves to support equilibrium and (b) the recording of these gains on the product side. It is argued that these two entries complete the accounting consistently with incentives and decisions and with findings elsewhere in economics.

2. Up the Two-Way Street: Resource Accounting

2.1. Wealth vs. welfare accounting

Wealth is the present value of consumption at the market rate, r_t . When there is a single consumption good, C , wealth can be defined as $V(t) = \int_t^{\infty} C_s \exp \left[- \int_t^s r_{\tau} d\tau \right] ds$, with C as numeraire. When there are many consumption goods they are aggregated using prices.

Wealth accounting is closely linked to the aim of economic accounting, namely, to evaluate decisions and their outcomes. Its conception of income is tied to capital theory: "If income equals consumption plus the change in total wealth, then we have a neatly self-contained and intuitive theory of income and wealth – income equals the return on total wealth..." (Hamilton and Ruta 2009: 56). The market values of wealth and of output are reported. In a distorted economy, shadow values are used.

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