Capital and Wealth Accounting:

A New Frontier for General Equilibrium Modeling?

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Minimal Bibliography


What is Wealth Accounting?

- Wealth Accounting is research project with the following main objectives:
  - (1) Provide a more comprehensive social accounting system to measure economic performance and well being within and across countries.
  - (2) Analyze and quantify tangible and intangible capital as a source of economic status and potential.
  - (3) Provide a new and more meaningful framework to measure economic growth and development.
  - (4) Focus on natural and human capital as drivers of growth and progress.
What is Capital?

- Capital is defined as the key argument of the production function, a concept that itself depends on the existence of capital as a means of production and is widely criticized.

- The Austrian school critique, for example claims that the production function is “out of time” and that, of the factors of production, capital (K) and labor (L), K is composed of heterogeneous production-goods that cannot be lumped together to give a physical quantity as an input.

- The Neo- Ricardian (Cambridge) objection was that in order to construct a measure of capital the time value for money (or the interest rate) was needed, but this led to circularity since capital was supposed to determine the interest rate.
The Austrian school definition for capital seems to identify a form of homogenous (financial ?) capital.

“Capital is properly defined as the subjectively perceived monetary value of the owner’s equity in the assets of a particular business unit. Capital is therefore to be sharply distinguished from capital goods.” (Kirzner 1996).

This suggests that capital may be a metaphor for what gives value to an enterprise. In other words, capital is a monetary representation of the value of the combined resources of the enterprise(s) considered.
What is natural capital?

According to a recent authoritative definition (Guerry et al. 2017), “Natural capital” refers to the living and nonliving components of ecosystems—other than people and what they manufacture—that contribute to the generation of goods and services of value for people.

Capital assets take many forms, including manufactured capital (buildings and machines), human capital (knowledge, skills, experience, and health), social capital (relationships and institutions), and financial capital (monetary wealth), as well as natural capital.

In this description, the asset aspect is dominant, but measurability is largely confined to the flow of services, or to some macroscopic aspects of otherwise elusive underlying sources of value.
Is All Capital Immaterial?

► Against a plurality of material (capital goods) and less material (capital services) references, the different types of capital evoke a common capacity to represent aspects of the production process by appealing to one or more immaterial elements.

► In the case of natural capital, the immaterial appeal is the concept of “nature”, or of elements of nature that, directly or indirectly, produce value for people. Such a value is produced by providing “ecosystem services”.
Is Capital different from wealth?

- Capital is «productive wealth», that is, it is part of wealth and can be used to create wealth.

- However, not all wealth can be considered capital. For example, residential housing is part of wealth but it is a consumer durable and is not used as a means of production. Financial assets are wealth but not capital in the production function sense.

- A recent definition (Piketty, 2011) is that capital (and wealth) is "the total market value of everything owned by the residents and government of a given country at a given point in time, provided that it can be traded on some market." This excludes non-traded capital. Also, asset price revaluations that are unrelated to changes in the value of marginal product of capital are counted as changes in the capital stock.
Importance

- How big is Capital? According to World Bank estimates, the ratio of produced wealth to GDP averages a factor of 2.6 across more than 120 countries and of a factor of 6.6 if some measures of tangible wealth, both produced and natural, are included.

- However, if income is understood as the return on wealth, and the rate of return is assumed at 5 per cent, then the total wealth of a nation should be in the order of 20 times GDP. Thus, missing tangible and intangible assets account for more than 93% of total wealth and a large part of this is human capital.
What is GDP?

- GDP is the most widely used measure of aggregate economic performance, but its nature, scope and economic rationale are not completely clear.

- It is based on a methodology fully established only in the mid-sixty and was/is the object of many controversies among statisticians and economists.

- In «The power of a single number», for example, Philipp Lepenies (2016) locates the origins of GDP measurements in Renaissance England and posits that it is exclusively based on a productivity approach to well being.

- A widely held view sees the GDP measure emerging naturally from a system of social accounting (SAM) concerning the creation of wealth in a national economy.
How is GDP related to social welfare (flow) and social wealth (stock)?

- Assume that social well being depends on the present value of aggregate consumption over an indefinite period of time.
- Assume also that the social wealth accumulates by sacrificing present consumption to accumulate various forms of capital (physical, human, capital). In turn, capital can be used to produce future consumption.
- Social well being = Present consumption + Increased potential for future consumption
- If only physical capital is considered and its opportunity cost is equal to the amount of consumption sacrificed to produce an equal amount of investment, it follows that: Social well being = Present consumption + Investment = GDP
General idea: we seek a good measure of present and future (potential) well being

- According with the neoclassical growth model, the objective of economic activity is to maximize over time the present value of social welfare, as function of the goods and services produced. To achieve the highest possible level of welfare, society faces a trade off between consumption and capital accumulation:
  - Maximize Social Welfare as a function of total consumption
  - Capital Growth = production (as a function of capital itself and other inputs) minus consumption
  - Positive and negative externalities may be associated with both production and consumption
GDP as present and potential well-being

The mathematical equivalent of the previous equalities are the basis of the Solow growth model:

(1) \( \text{Max } \int_0^T W(C(t)) dt \); \( \dot{K} = F(K, L) - C(t) - \theta K(t) \)

The Hamiltonian is the sum of present and potential well-being (in mechanics it is the sum of kinetic and potential energy) and its maximum coincides with the maximum of the dynamic system in (1):

(2) \( H = W(C) + \pi \dot{K} \)

First order conditions require: \( W_C = \pi \), so that, approximating linearly the welfare function in (2) and dividing by \( W_C \), we obtain:

(3) \( H/W_C = C + \dot{K} = \text{GDP} \)

Thus GDP is a linear approximation of the Hamiltonian and incorporates some relevant information on the present course of an economy as well as its potential growth, measured at shadow prices (marginal utility of consumption)
The aggregate model extended to natural capital

\[ \text{Max } \int_0^\infty e^{-\rho t} U(C(t), N(t)) dt \]

\[ \dot{K} = -\theta K + F(K(t), Q(t)) - C(t) - f(K(t), Q(t)) - h(K(t)) \]

\[ \dot{N} = \mu N(t) \left( 1 - \frac{N(t)}{N_M(t)} \right) - \gamma Q(t) \]

\[ N_M(t) = h(K(t)) \]

Maximize present value of utility from consumption and non use value of natural capital subject to the dynamics of the stock variables.

Both Physical \( K(t) \) and Natural capital \( N(t) \) are linked to ecosystem services \( Q(t) \) by their laws of motion.

\( N_M(t) \) is the maximum carrying capacity of the environment.
Optimal growth conditions

(1) \( \frac{\partial H}{\partial C} = U_C - \varphi = 0 \)

Shadow price of physical capital = marginal utility of consumption

(2) \( \frac{\partial H}{\partial Q} = \varphi (F_Q - f_Q) - \psi \gamma = 0 \)

Shadow price of natural capital = marginal rents
Net National Product (NNP) as Economic Potential

Applying optimality conditions, and a linear approximation to the welfare function, we derive a simple expression for NNP from the Hamiltonian:

\[
\text{NNP} = \frac{H}{U_C} = C + \dot{K} + \frac{1}{\gamma} \left[ (F_Q - f_Q) \right] \dot{N}
\]

NNP = Net National Product = Economy’s potential at shadow prices = consumption + physical capital formation + (net rents) x value of natural capital formation (or destruction)
Shadow Prices of Natural Capital from additional optimality conditions

\[ (3) \psi = U_C \frac{F_Q - f_Q}{\gamma} \]

= marginal users’ value of natural capital (derived demand price)

\[ (4) \psi = \frac{U_N + \dot{\psi}}{e - \mu(1 - \frac{2N}{N_M})} \]

= marginal non users’ value of natural capital (supply price)

These equations hold also off the optimal path, provided some «local» best reaction is assured
The Current Hamiltonian and the Net National Product in the More General Case (No optimization required)

- Differentiating \( V(t) = \int_t^\infty e^{-\rho(\tau-t)} U(C(\tau), N(t), W(t)) \, d\tau \):

\[
dV(t) = -U(C(\tau), N(t), W(t)) + \rho V(t)
\]

By definition, the change in the value function is the sum of the value changes of the underlying assets at shadow prices:

\[
dV(t) = p_K \dot{K} + p_N \dot{N} + p_W \dot{W}
\]

- Thus:

\[
H(t) = \rho V(t) = U(C(\tau), N(t), W(t)) + p_K \dot{K} + p_N \dot{N} + p_W \dot{W}
\]

\( H(t) \) is the current Hamiltonian or the current equivalent of the present value of future utility from consumption, natural and human capital. Its linear approximation is the Net National Product (NNP).
NNP provides a new interpretation for growth

NNP provides a new interpretation for economic growth consistent with the NNP rule:

Growth = Increase in a country’s economic potential = Increase in current consumption (dividend) + Increase in extended capital formation (capital gain) evaluated at shadow prices.

Since the capital formation that is accounted for is only a small proportion of the total, current growth statistics are misleading.
Shadow Prices for Wealth Accounting

Differentiating the Hamiltonian with respect to the various forms of capital:

\[ \frac{\partial V}{\partial K} = (\rho + \theta) p_K = p_K \Omega_K + \dot{p}_K \rightarrow p_K = \frac{\dot{p}_K}{(\rho + \theta) - \Omega_K (\lambda \beta c)} \]

\[ \frac{\partial V}{\partial N} = \rho p_N = U_N - p_N \mu \left(1 - \frac{2N}{N_M}\right) + \dot{p}_N \rightarrow p_N = \frac{U_N + \dot{p}_N}{\rho - \mu \left(1 - \frac{2N}{N_M}\right)} \]

\[ \frac{\partial V}{\partial W} = \rho p_W = U_W - p_W \omega + \dot{p}_W \rightarrow p_W = \frac{U_W + \dot{p}_W}{\rho - \omega} \]

These shadow prices represent opportunity costs of the three forms of capital: physical, natural and human. Their expression is not dependent on optimizing conditions.
Shadow prices as functions of ecosystem services use

Index of Consumption of Natural Capital Services

Supply price
Demand price
Are Shadow Prices Close to Market Prices?

**VALUE ESTIMATES** for Ecosystem Services and Natural Capital

US$/Ha  Source: Scandizzo and Cufari META-ANALYSIS (2017)

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Properties of shadow prices of natural capital in theory and in fact

- Expectations and uncertainty about future scarcity potentially important (option values)
- Higher resiliency (higher intrinsic rates of reproduction) imply higher shadow prices
- Higher stock sizes compared to carrying capacity imply lower shadow prices
- WTPs appear dominated by non use values and, among these, by existence values
- Except for fisheries, average values are much above median values
Principles of accounting for natural capital in SAM-CGE models

- Productive sectors utilize natural resources as inputs in production processes.
- Because of lack of property rights and of proper markets, natural resources uses are generally not priced efficiently to reflect their opportunity costs.
- Net rents arise from the differences between the values of their productive contribution and users' costs (extraction, maintenance and servicing).
- Under-remunerating natural resources tends to cause damages to natural capital ranging from deterioration to depletion.
- These damages can be quantified as forms of depreciation and/or through increasing shadow prices.
Problems with the CGE-social accounting approach

- Under-remuneration of natural resources does not necessarily cause damages or depletion of natural capital. These may depend on thresholds (e.g., maximum sustainable yields) or on bifurcation points, including regime abrupt changes and ecosystem collapse.

- For natural resources that are internationally traded, under-remuneration may be the responsibility of the buyers, which are mostly developed countries. Parallel to asset reductions in the exporting countries, liabilities arise in the importing ones.

- More generally, many natural resources can be considered non-local or global public goods.
Kenya: An Example of an Environmental SAM-CGE (M US$)

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Kenya: Estimates with the CGE Model (M US$)

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<th>Differences</th>
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Natural capital shortfall: -10,046.90
Kenya: Comparison between GDP and NNP

**GDP and NNP Components**

- Sales of stores
- Sales of services
- Non-traded services
- Capital
- Land
- Agriculture:
  - Water resources
  - Non-renewable natural resources

**GDP versus NNP**

At market prices

- GDP
- NNP

At shadow prices

- GDP
- NNP

Natural capital shortfall

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<th>GDP versus NNP</th>
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At market prices

- NNP
- GDP

At shadow prices

- NNP
- GDP

Difference

- NNP
- GDP
Conclusions

- Wealth Accounting (WA) is a proper extension of the neoclassical economic model. As such, it can usefully complement theory and measurement of economic performance.

- Unlike traditional accounting, WA has to cope with absent or imperfect property rights, with externalities being the norm rather than the exception. Estimating shadow prices is thus important.

- WA measurement is key to a better understanding of economic development. Because of many recent advances both in theory and measurements, CGE (dynamic) modelling appears the best approach to provide insights and guidance for good estimates of shadow prices.