Analysis

Assessment of the theory of comprehensive national accounting with data for Portugal

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ARTICLE INFO

ABSTRACT

We present time-series tests of the quality of genuine savings and green net national income for predicting welfare changes. These tests check the validity of the theory of comprehensive national accounting, and more broadly of the theory of economic growth. The value of technological progress is included, as well as the effects of business cycles. We use estimates for Portugal as inputs. Overall, our results indicate that both genuine savings and changes in green net national income have the same sign as changes in welfare, but reject the hypothesis that the estimated comprehensive national accounting measures coincide with the theoretical expressions. The results also suggest that comprehensive accounting indicators perform better than conventional national accounting indicators, implying that, in general, the corrections proposed by the comprehensive accounting theory add explanatory power to conventional measures. The exception is the inclusion of education expenditures and technological progress, which decrease explanatory power. Excluding business cycles from green net national income increases the agreement with the theory. Comparing both indicators, in general, genuine savings presents better results.

1. Introduction

The evidence to test the theoretical results that comprehensive national accounting indicators (i.e., green net national income, GNNI, and genuine savings, GS) can predict changes in welfare (e.g., the sum of discounted utilities) is scarce, in contrast to the considerable effort which has been devoted to estimating these indicators.

The theory of comprehensive national accounting (also known as green accounting) was motivated by the need to assess the sustainable development of countries with indicators firmly grounded in economic theory. The interest is in obtaining relationships between national accounting quantities and welfare to make over-time welfare comparisons within economies. The fundamental result was provided by Weitzman's (1976) seminal paper, where it was shown that the current comprehensive net national income, measured as the sum of consumption and net investment, is proportional to the current maximum welfare attainable along the optimal path. From this result it is easy to show that average future consumption will be above (below) current consumption if and only if a measure of comprehensive net investment is positive

(negative) (Hamilton and Clemens, 1999). Since Weitzman (1976), the understanding of green accounting indicators has been extended by the study of models with less restrictive assumptions (e.g., Asheim, 2007), or models focused on particular types of natural capital or environmental services (e.g., Hartwick, 1990). In general, the comprehensive measure of net income is called green net national income, (GNNI),[1] whereas the comprehensive measure of net investments is called genuine savings (GS). GS and GNNI (actually green net national product) first appeared in the literature in, respectively, Hamilton (1994) and Hamilton and Atkinson (1996).

Through the work of Hamilton and others, the World Bank[2] provides yearly estimates of GS (now called Adjusted Net Savings) for 210 countries since the year 1970. Their estimates include the depletion of nonrenewable resources and forests (considering only wood production), the impact of CO_2 and of particulate matter emissions and the investment in human capital (education expenditures). The order of magnitude of the environmental terms included is small when compared

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[1] In fact, most of the papers mention Green Net National Product. Here we choose the income version rather than the product version, to emphasize that it is the income version that should be used for welfare accounting.
[2] Available at http://www.worldbank.org.

with the conventional economic terms but it varies significantly from low to high income countries. For low income countries (resp. high income) net forest depletion is around 1.2% (0.05%) of GNI, energy depletion is around 1.4% (0.7%) of GNI, mineral depletion averages 1.2% (0.2%) of GNI, the damage from CO_2 emissions is around 0.3% (0.2%) of GNI and from particulate matter is 0.5% (0.1%) of GNI (World Bank, 2012).

Given the attention received, there should, ideally, be firm evidence that greener national accounts aggregates are indeed better indicators of welfare changes than conventional indicators. This is still not the case, although efforts have been made to check the consistency of the theory and the predictive accuracy of GS and GNNI as we observe in Section 3 below.

The theory of comprehensive national accounting basically uses a conventional model of economic growth. Therefore, its econometric testing can be understood as a direct test of the validity of conventional economic growth theory. The theory concerns an economy that is developing along an optimal trajectory. Typically it is assumed that the development is close to the optimal path, and that the aggregates estimated account for changes in the most important forms of capital and direct contributors to utility.

When testing the theory of comprehensive national accounting many caveats are implicit in the analysis. Measurement errors may be significant, even for conventional indicators used in the system of national accounts (SNA). Moreover, the measurement errors in the depletion of natural capital, human capital (as proxied by education expenditures), and technological progress are certainly non-negligible. In particular, technological progress is an important contributor to the estimated values of GNNI and GS (Weitzman, 1997), and it is very much dependent on projections of future technological progress (Mota et al., 2010). Moreover, the existing data for TFP may not be adequate to the green accounting models since growth accounting expressions used to calculate TFP do not include environmental resources or pollution as inputs in production. It is not clear whether the TFP over- or underestimates the relevant TFP to be used in comprehensive accounting models. Even having solved these drawbacks, it may still be the case that the underlying assumptions of economic growth models do not hold, and the theory would still fail its empirical tests.

In this paper we contribute to the existing literature on tests of comprehensive national accounting by using time series techniques for a single country, as the testable expressions are derived for within country over-time welfare comparisons. A detailed literature review is presented below, in Section 3, after the range of testable expressions has been presented in Section 2. We use as inputs the time-series of GNNI and GS estimated for Portugal (Mota et al., 2010). Besides the common adjustments for minerals and roundwood resource depletion we include the set of flow pollutants that are most important for human health according to the European Commission (Holland et al., 2005), and the value of technological progress as estimated by total factor productivity (TFP), and we check the impact of the effects of business cycles by using potential GNNI. Moreover, in accordance with the theory (Asheim and Weitzman, 2001), the green accounting measures are deflated using a Consumer Price Index (CPI).

This paper is organized as follows. The next section summarizes the theory that derives the various welfare interpretations of GNNI and GS and presents the associated testable expressions. In Section 2, we also refer the literature that has tested them, which is further discussed in the detailed empirical literature review in Section 3. Section 4 presents the data used, the way the variables were estimated or constructed and the results of the econometric tests. Section 5 concludes.

2. The Theory of Comprehensive National Accounting

In this section we present the expressions that allow direct tests of the theory of comprehensive national accounting.

The model conventionally used in the literature assumes a representative agent, competitive, open economy with constant population. Although we present the results using a discounted utilitarian setting this need not be the case, as shown in Asheim (2007). The consumption bundle C(t) contains everything that influences utility $U(C(t))$,[3] including all non-market commodities (environmental or produced at home) and amenities. The economy's capital stocks include man-made, foreign, natural and human capital, forming a vector K(t). Welfare is defined as $W(t) \equiv \int_t^\infty U(C(s))e^{-\rho(s-t)}ds$, with a constant and positive utility discount rate, ρ. The vectors of real Divisia prices of consumption and investment goods are respectively **P** and **Q**, and the price associated with the passage of time (e.g., technological progress or changing terms of trade) is Q^t, as in Pezzey (2004). In this setting, GNNI is defined as $Y = P \cdot C + Q \cdot I + Q^t$, and GS as $GS = Q \cdot I + Q^t$. Following Asheim and Weitzman (2001), if an extended Divisia consumer price index (CPI) Λ is used (to deflate GNNI) the following expression holds on the optimal path

$$\dot{Y} = R\left(Q \cdot I + Q^t\right) = \frac{R}{\Lambda}\ \dot{W}, \tag{1}$$

where is the real interest rate. The property that defines a Divisia CPI is $\dot{\mathbf{P}} \cdot \mathbf{C} = 0$ (Asheim and Weitzman, 2001).

The first equality in expression (1) provides a direct test of the model and was investigated in Pezzey et al. (2006). Note that, as shown in Asheim and Weitzman (2001), for the GNNI to measure welfare changes it is necessary to use real (instead of nominal) GNNI deflated by a generalized consumer price index that includes all consumption goods that influence utility. Only consumption goods should be used as quantity weights in the price index (proposition 1 of Asheim, 2007).

It is also worth mentioning that the models of comprehensive national accounting require the use of potential GNNI since the theory assumes full capacity utilization at all times. Pezzey et al. (2006) estimate that business cycles have a sizeable impact on actual GNNI, and in Mota et al. (2010) the results indicate that business cycles affect the message of sustainability of GNNI.

Regarding the other testable expressions of the theory of comprehensive national accounting it is known that, with a constant interest rate R, the present value of future changes in consumption must equal the value of net investments (Asheim, 2007; Dixit et al., 1980; Hamilton and Hartwick, 2005),

$$PV\Delta C_t \equiv \int_t^\infty (\mathbf{P}_s\dot{\mathbf{C}}_s)e^{-R(s-t)}ds = GS_t. \tag{2}$$

This is the expression Hamilton (2005) and Ferreira et al. (2008) use to test the World Bank's GS estimates. Using Eq. (1) in Eq. (2), we obtain an equivalent expression for the change in GNNI,

$$PV\Delta C_t = \frac{\dot{Y}_t}{R} \tag{3}$$

which has not been estimated as far as our literature review could identify.

Using the results of Asheim and Weitzman (2001), for a constant real interest rate it is possible to show that the present value of consumption at time t obeys

$$PVC_t \equiv \int_t^\infty \mathbf{P}_s \cdot \mathbf{C}_s e^{-R(s-t)}ds = \frac{Y_t}{R}. \tag{4}$$

This equation is used in Vincent (2001) to test the GNNI estimates.

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[3] The convention throughout the text is that vectors are represented in bold.