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Measuring Regional Welfare Considering Natural and Cultural Resources[1]

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Abstract

The aim of this paper is to explore some of the theoretical aspects of measuring welfare in regional economies using a simple dynamic growth model. The focus is on natural and cultural resources, which are treated as capital stocks in the analysis. We use the concept of a social accounting matrix (SAM) to illustrate how the addition of income flows and net changes of various natural and cultural resources can be incorporated into a measure of welfare that is more complete compared to the standard net regional product/income. Furthermore, we propose how the set a theoretically "optimal" subsidy to compensate a cultural sector – in our example engaged in the pastoral activity of reindeer herding - for maintaining and upholding a cultural heritage.

***Keywords**: capital theory, cultural capital, dynamic economy, natural capital, SAM.*

Introduction

The purpose of this paper is to shed some light on the theoretical aspects of measuring welfare in regional economies with focus on natural and cultural resources. We will use the concept of a social accounting matrix (SAM) to illustrate how the addition income flows and depreciations of various natural and cultural resources can, theoretically, be incorporated into a more complete measure of regional welfare.

Measuring comprehensive welfare indices at the national level has been an important and vibrant part of economics research for a long time. National income accounts became important in the 1940s, to aid macro-economic policy analysis. The accounts were designed to provide detailed information about e.g. total supply and total demand, savings and investments in man made capital, and imports and exports. Gross national product (GNP, a value of production in a country) has been used to indicate the welfare of a nation. Criticisms against GNP are plentiful; one argument being that GNP is a gross measure and should be replaced by net national product, NNP, where capital depreciation is included. NNP, however, may still be a poor measure of welfare because it does not treat environmental and natural resources. Numerous attempts to augment the traditional NNP measure to include environmental and resource stocks and flows are now available (see e.g. Heal and Kriström, 2002, and references therein). One major conclusion is that depreciation/appreciation terms of stocks (man-made, natural, etc) in an economy appear on the product or expenditure side of the economy (see e.g. Hartwick, 2001, or Mäler, 1991). Also, income terms, such as interest on various stocks, have been suggested to be included on the income side of the economy. Hultkrantz (1992) outlines an extension of the national accounts in Sweden to include various flows from the forest resource stock. He finds that the total net value added provided by forest resources and forestry labor in 1987 was 22 billions SEK, which is one third more than the contribution of forestry to the “conventional” GNP.

Natural and environmental resources are potentially even more important when looking at regional welfare; especially in regions with many and vast natural and environmental resources. An example of such a region is the Swedish mountain region. Pristine and scenic landscape, clean air and water, various game and predator populations, extensive forest resources, are just a few examples of natural and environmental resources that can be found in this region. Also, the indigenous population, the Saami people, contribute to a cultural resource stock by operating reindeer husbandry and by various other activities that potentially affect other economic output or utility in the region. Theoretical and practical analyses of natural resources and their importance on a regional level is scarce in the literature. Prudham and Lonergan (1993) outline and discuss how practical regional resource accounting could be performed along the lines of the theoretical literature. In principal, this means adjusting income and production accounts to include flows and depreciation from natural resources. Comments and experiences with practical regional SAM building in general, not focusing on natural resources, can be found in Schwarm and Cutler (2003). Cultural capital and analyses of its interactions with an economy is not very common, at least to our knowledge, in the literature.[3] Social capital has been suggested to be the missing link in growth theory aside from human, man-made, and natural capital.[4] Cultural capital or resources is somewhat similar to the notion of social capital as it tries to account for social structures and other intangible assets connected to cultural heritage.

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[3] A few attempts have been made though; see e.g. Throsby (1995, and 1999).
[4] See Grooteart (1998).

The paper is organized as follows. First we describe a benchmark model with human capital and discuss how the model output can be incorporated into a SAM framework. We then proceed to include natural capital into the model to see how this changes the concept of welfare in the economy. Finally - and to our knowledge novel - we suggest how cultural capital can be incorporated into the model (and the SAM), focusing specifically on the pastoral Saami culture of northern Scandinavia (and parts of Russia).

Natural resources

Throughout the paper we will use the framework developed by Hartwick (2000 and 2001) to describe how the inclusion of natural and cultural resources in a simple dynamic model of an economy can alter the notion of regional income and production.[5] We begin by outlining a simple endogenous growth model as our benchmark (with endogenous technical change)[6]. This is an economy in balanced growth to which other non-balanced growth models can be compared. We illustrate by using a SAM framework as suggested by Hartwick (2001).[7]

The benchmark model

Consider a stock $A(t)$ which is augmented at each point in time by some direct effort, i.e. dA/dt is produced using certain inputs or primary factors. The production of consumption and investment goods can be described by

$$C(t) + I(t) = f(K(t), [L - L_1(t)]A(t)) \qquad (1)$$

[5] The presentation in this section relies heavy on Hartwick (2001). However, we explicitly introduce man-made capital depreciation into the model, and a discussion about cultural capital. For more details, discussion and further references consult Hartwick (2000 and 2001).
[6] Endogenous technical change within a specific region of a small nation is perhaps a questionable assumption. However, with endogenous technical change modeled in this fashion, it is possible to derive a benchmark model exhibiting balanced growth, which is convenient for illustrative purposes.
[7] Mäler (1991) also used a SAM to illustrate accounting for the environment.

where K is man-made capital, $I(t) = dK(t)/dt + \delta K(t)$ is gross investment (δ is depreciation rate of K-capital), $C(t)$ is consumption, L is a fixed amount of workers in the economy, $L_1(t)$ is amount of workers in the sector that produce knowledge, $A(t)$ is the current stock of knowledge (or some other measure of human capital, e.g. amount of people with higher education), and $f(\cdot)$ is a neo-classical production function exhibiting constant returns to scale. Furthermore, knowledge is produced according to

$$dA(t)/dt = aL_1(t)A(t) \qquad (2)$$

with $a > 0$. The social planner or the market seeks to maximize the region's discounted flow of utility from current period $t = 0$ to infinity - where we denote time t utility $U(C(t))$ and the discount rate r - subject to (1) and (2), and with $U(0) = 0$, $K(0) = K_0$, and $A(0) = A_0$. The current value Hamiltonian is (suppressing time index)

$$H = U(C) + \lambda\{f(K,[L - L_1]A) - C - \delta K\} + \mu a L_1 A$$

where λ and μ are time varying co-state variables (shadow prices). Setting $X = [L - L_1]A$, the optimality conditions are

$$dH/dC = 0 \qquad \text{or} \qquad U_C = \lambda \qquad (3)$$

$$dH/dL_1 = 0 \qquad \text{or} \qquad \lambda f_X = \mu a \qquad (4)$$

$$- dH/dK = d\lambda/dt - r\lambda \qquad \text{or} \qquad r - (d\lambda/dt)/\lambda = f_K - \delta \qquad (5)$$

$$- dH/dA = d\mu/dt - r\mu \quad \text{or} \quad -\lambda f_X[L - L_1] - \mu a L_1 = d\mu/dt - r\mu \qquad (6)$$

The market interest rate is defined as $i_K = r - (d\lambda/dt)/\lambda$ (condition 5). The usual transversality conditions associated with infinite optimal control problems also applies.

Let us summarize these conditions in a social accounting matrix form (table 1). The matrix is constructed so that row sums equals the corresponding column sums. Receipts are inserted in rows and expenditures in columns. The procedure for filling in the cells (see Hartwick, 2001) is as follows. Divide everywhere with $U_C = \lambda$ and then multiply each flow and state optimal condition equation with its corresponding variable. That is, equation (5) is multiplied by K, and the result is inserted as the second column-row pair in table 1. Then use (4), (6) and (2) to obtain the third column-row pair.[8] In the first column-row pair we make use of constant returns to scale in $f(\cdot)$,[9] i.e., the value of output, $C + I$, is equivalent to the value of the inputs under marginal product pricing, $Kf_K + Xf_X$. The right hand column is the current value Hamiltonian normalized by U_C (= λ). By dividing by marginal utility we convert the flows from utils to numeraire units, for example SEK. The household column is now the linearized, SEK-valued, current value Hamiltonian (LSCVH), which in national accounting has been suggested to represent net national product (see e.g. Mäler, 1991, or Weitzman, 1999). The regional counterpart would be net regional product (NRP) . The term $(\mu/\lambda)dA/dt$ is the economic appreciation/depreciation of the knowledge stock A, and $-\delta K$ is "wear and tear" of man-made capital. The household row is net regional income (NRI), i.e., flows from the primary factors man-made capital and labor. The A-rate of interest, $i_A = r - (d\mu/dt)/\mu$, is not observable on the market. However, recognizing that $i_K = r - (d\lambda/dt)/\lambda$ is observable, we can write

[8] Multiply by X and A into (4) and (6) respectively, use $X = [L-L_1]A$ where possible, set $a = (\lambda/\mu)f_X$, and use (2) to set $aL_1A = dA/dt$.
[9] Euler's homogeneity theorem.

$$(\mu/\lambda)\ [r - (d\mu/dt)/\mu]A = i_K(\mu/\lambda)A - [d(\mu/\lambda)/dt]A$$

where the bracketed term on the right hand side is relative price change of the stock of knowledge. With this in mind, we can write NRI (household row)

$$Ki_K + i_K(\mu/\lambda)A - [d(\mu/\lambda)/dt]A$$

The first two terms are the interest income flows from the two stocks, and the last term represents a capital goods price change for knowledge. As long as we have unbalanced growth, the ratio of K and A is changing, the relative capital goods price will be changing. In balanced growth[10], the ratio of K and A is constant, relative capital goods price is also constant and thus the price changes will disappear and are not entered in the SAM. This means that in unbalanced growth (which is the natural state) an "anomaly" occurs in the form of a capital gains term in NRI. In balanced growth, NRI is simply $Ki_K + i_K(\mu/\lambda)A$.

In sum: normalize optimal conditions by dividing by $U_C = \lambda$ to obtain SEK-values, multiply each optimality condition with its "corresponding variable", and then insert them into the corresponding accounts in the SAM; Linearize the utility function U before inserting it into the SAM (to get C in the table). The SAM is now organized so that the LSCVH or NRP appears in the household column.

[10] See e.g. Weitzman (2000) for a derivation of the conditions under which balanced growth can occur.

Table 1. Social accounting matrix (knowledge or human capital associated with labor)

Reciepts → Expenditures ↓	Consumption and K-investment	K	L	H
Consumption and K-investment				$C + I$
K	Kf_K			$- \delta K$
L	Xf_X			$(\mu/\lambda) dA/dt$
H		Ki_K	$(\mu/\lambda)\ [r - (d\mu/dt)/\mu]A$	

Natural resources

We proceed to vary the benchmark model to include different types of natural capital: non-renewable and renewable resources.

Non-renewable resources

Consider an economy based on extraction of a non-renewable and finite resource (e.g. oil or natural gas) as input in production of goods. In this case, balanced growth can be ruled out and capital gains terms are sure to show up in the NRI as shown in the analysis above.

$G(t)$ is the time t stock of the resource and it is extracted according to (suppressing time index)

$$dG/dt = - g(G,L_1)$$

where L_1 is labor used in mining and $g(\cdot)$ is an extraction function which is homogenous of degree unity in its arguments.[11] Goods production (constant returns to scale) has three inputs

$$C + I = f(K,L - L_1,g(G,L_1))$$

where C is consumption, $I = dK/dt + \delta K$ is gross investment in K (man-made capital), and L is a fixed stock of labor. $U(C)$ is a concave utility function and the economy maximizes present value of the infinite flow of utility with discount rate r. Setting $X = L - L_1$, the current value Hamiltonian is

[11] We abstract from incorporating K-capital in the extraction function. It would be reasonable to do so, but it makes the derivation of table inserts considerable more complex with little benefit.

$$H = U(C) + \lambda[f(K,X,g(G,L_1)) - C - \delta K\ ] - \mu g(G,L_1)$$

Again, λ and μ are time varying co-state variables (prices). The resulting optimality conditions are then

$$dH/dC = 0 \quad \text{or} \quad U_C = \lambda \qquad (7)$$

$$dH/dL_1 = 0 \quad \text{or} \quad [f_X - f_g g_{L1}]\lambda + \mu g_{L1} = 0 \qquad (8)$$

$$- dH/dK = d\lambda/dt - r\lambda \quad \text{or} \quad r - (d\lambda/dt)/\lambda = \ i_K = f_K - \delta \qquad (9)$$

$$- dH/dG = d\mu/dt - r\mu \quad \text{or} \quad r - (d\mu/dt)/\mu = f_g g_G(\lambda\ /\mu) - g_G \qquad (10)$$

Now insert these conditions into the SAM in table 2 as shown earlier. As before, when inserting the first column-row pair we make use of Euler's homogeneity theorem in $f(\cdot)$ (marginal product pricing). The second column-row pair is condition (9). Labor allocation is summarized in condition (10), which is inserted after adding and subtracting gf_g. Recognizing that

$$g = L_1 g_{L1} + G g_G = -\ dG/dt \qquad \text{(i.e. homogeneity of degree 1 in } g\text{)}$$

the household column, net regional product, can be simplified to read

$$C + I - \delta K +\ (\mu/\lambda)dG/dt$$

which simply says that NRP is consumption and investment less the SEK-valued depreciation in stocks K and G; it is the linearized, SEK-valued, current value Hamiltonian. Remember dG/dt is negative so there is disinvestment in the natural stock over time. The household income row is net regional income, and $d\mu/dt$ – price change of the natural stock - is positive since the stock G is becoming increasingly scarce as time passes by. Using $i_K = r - (d\lambda/dt)/\lambda$ we reformulate the G-rate of interest $i_G = r - (d\mu/dt)/\mu$ so that

$$i_K(\mu/\lambda)G - [d(\mu/\lambda)/dt]G$$

Now the household row, NRI, is

$$K\, i_K + Lf_X + i_K(\mu/\lambda)G - [d(\mu/\lambda)/dt]G$$

The first three terms are income from man-made capital, labor, and natural capital respectively. The last term is capital gains on natural capital that occurs due to changing stock price.

Some non-renewable resources, like gold and copper, can be considered durable since they are not consumed in one single period. For example, gold and copper can be recycled. This kind of resource is non-renewable and finite, but it can still yield services over many periods after extraction. See Levhari and Pindyck (1981) or Hartwick (2001) for a model that accounts for recycling.

In sum; NRP is augmented with a term representing natural resource depreciation, and NRI is augmented with interest income on stock *G*, and a capital gains term since the price of *G* is steadily increasing over time.

Table 2. Social accounting matrix (non-renewable resource, *G*-capital)

Reciepts → Expenditures ↓	Consumption and *K*-investment	K	L	G	H
Consumption and *K*-investment					$C + I$
K	Kf_K				$- \delta K$
L	Xf_X				$- g_{L1}(\mu/\lambda - f_g)L_1$
G	gf_g				$- g_G(\mu/\lambda - f_g)g_G G - gf_g$
H		Ki_K	Lf_X	$(\mu/\lambda)[r - (d\mu/dt)/\mu]G$	

Renewable resources

Renewable resources, such as a forest or a fish population, are characterized by the ability to regenerate. We assume the growth over time of the renewable resource is logistic. This introduces a non-linearity in the accounts, which will create a residual income entry in NRI.[12] We modify the extraction model to include growth so that

$$dG/dt = z(G) - g(G,L_1)$$

where $z(G)$ is the standard growth function with inverse U-shape and $z(0) = 0$. This modification does not change the NRP in table 2, but NRI contains a new term

$$(\mu/\lambda)[z - z_G G]$$

and the modified NRI now reads

$$Ki_K + Lf_X + i_K(\mu/\lambda)G - [d(\mu/\lambda)/dt]G + (\mu/\lambda)[z - z_G G]$$

This last term is a surplus or income collected by the resource harvester.

Cultural resources

In the analysis above we have incorporated the three principal forms of capital that can be found in the economics literature; 1) man-made capital, 2) knowledge or human capital, and 3) natural capital. Social capital has also been suggested to be an important factor affecting welfare and economic development. Social capital includes the social and political

[12] Similar to the residual incomes that appear in standard national accounting when returns to scale in production of goods are non-constant.

environment which facilitates norm development and shape social structure.[13] In a similar fashion cultural capital potentially have an impact on an economy and its agents. The term "culture" is used in a wide variety of contexts to mean many different things. A recent attempt to come to terms with culture in the specific context of economic activities and can be found in a report of the U.N. World Commission on Culture and Development (WCCD, 1995). The report has two interpretations of culture. The first one defines culture as a set of activities undertaken within the so-called "cultural industries". Culture can thus be thought of as being represented by a "cultural sector" of an economy. Economic activities associated with this cultural sector could be a variety of different things. It could be arts and/or music, or some economic activity connected to some cultural heritage such as reindeer herding performed by indigenous Saami people in northern Sweden. The second interpretation is that culture is expressed in a particular society's values or customs, which evolve over time as they are transmitted from one generation to another (see also Throsby, 1995). Accepting these interpretations, we are able to define cultural capital as an asset that contributes to cultural and economic value. More specifically, cultural capital is the stock of cultural value embodied in an asset (Throsby, 1999). This stock give rise to a flow of goods and services over time, i.e., to commodities which themselves may have both cultural and economic value. The asset may be tangible or intangible. Tangible cultural assets exist in buildings, structures, sites and locations endowed with cultural significance. Intangible cultural capital is a set of ideas, practices, beliefs, traditions and values that serve to identify and bind together a given group of people. Both tangible and intangible cultural assets give rise to a flow of services, negative or positive, which may form a part of private final consumption.

[13] For an overview and discussion of the social capital literature see Grootaert (1998).

Now let us try to incorporate the notion of cultural capital into economic analysis. There is likely to be a correlation between the cultural value and the economic value of items of cultural capital, but the relationship is by no means a perfect one. The causal direction is likely to be that cultural value augment economic value. The question is what impact cultural capital has on economic output. As mentioned before, neo-classical models of economics have been developed to include both human and natural capital in addition to physical or man-made capital. Human capital has been shown to be important in endogenous growth modelling (see e.g. Aghion and Howitt, 1998), and as we shown above, natural capital can be added to the picture improving descriptive and predictive power of such models. Specifying a production function that accounts for cultural capital could provide insights into, e.g., substitutability between different types of capital (if it exists). A useful specification of such a production function would be one that is articulated both in terms of economic and cultural value and their contribution to output. Throsby (1999) suggest the following general dynamic specification of the stock of cultural capital

$$dK^c(t)/dt = [I^{c,m}(t) - \delta^c(t)K^c(t)] + I^{c,n}(t)$$

where (suppressing time index), K^c is the stock of cultural capital, $I^{c,m}$ is maintenance investment, δ^c is the depreciation rate, and $I^{c,n}$ is new investment in the cultural stock. This is basically the standard physical capital equation of motion found in the economics literature (recognizing that $I^{c,m} + I^{c,n}$ = gross investment). This specification is "blunt" and not very useful since it does not specify exactly what new investment in culture is or how it affects the economy. Including this in a model of an economy would simply mean that an additional capital stock is added to operate in the production function. However, the crucial problem is to define what exactly new investment in the cultural stock is and how it affects the economy.

It is, for example, reasonable to believe that culture capital enters foremost as an argument in the utility function, and not necessarily the production function.

Instead, let us focus ideas and think of a particular cultural phenomena; the Saami culture found in the mountain region of north Sweden. The Saami are an indigenous people and are spread out in the north of Scandinavia and parts of Russia. The core feature of their culture is reindeer herding. Beside this main occupation, they also manufacture and sell Saami art-work and contribute to the tourism sector in various ways by maintaining a cultural heritage. How can we incorporate this cultural stock and its contributions into a model of the local economy?

Since reindeer herding is the core activity in the Saami culture and has been for a long time, we first specify a dynamic equation for this renewable resource (suppressing time index):

$$dR/dt = z(R) - g(R,L_1) \tag{11}$$

where R is the stock of reindeers, and L_1 is the amount of labor used in reindeer herding $z(R)$ is an inverted U-shaped biomass growth function, and $g(\cdot)$ is the harvest production function (which is assumed homogenous of degree unity in its arguments, R and L_1). The harvest $g(\cdot)$ is used as input to produce consumer goods (basically reindeer meat). Assume further that the change in the cultural stock, dS/dt, depends on current cultural stock, S, some exogenously given policy parameter vector, $\mathbf{x}$,[14] and the level of the current reindeer stock, R. We write this relationship as follows

$$dS/dt = h(R,S,\mathbf{x}) \tag{12}$$

[14] The most relevant policy parameters being the per kilo meat SEK subsidy, and a subsidy for predator killed reindeers. However, other parameters such as the Saami people's right to use certain land areas also have an important impact on the development of the Saami culture.

Furthermore, we assume, for simplicity, that h is homogenous of degree unity in its arguments. Furthermore, assume that production of consumer and investment goods is given by

$$C + I = f(K, L - L_1, g(R, L_1)) \qquad (13)$$

where (as before) C is consumption, $I = dK/dt + \delta K$ is gross investment in man-made capital, and L is the fixed amount of total labor in the region (production is assumed homogenous of degree unity in its arguments).

The utility function has consumption and culture as arguments and is separable:

$$U(C, S) = U(u^C(C), u^S(S)) = u^C(C) + u^S(S)$$

The economy strives to maximize the discounted infinite flow of utility such that equations (11)-(13) and initial conditions $K(0) = K_0$, $R(0) = R_0$, and $S(0) = S_0$ are satisfied. We assume that the first derivatives of $U(\cdot)$ w.r.t. C and S are positive and the second derivatives are negative to ensure maxima. The current value Hamiltonian for this problem is

$$H = U(C, S) + \lambda[f(K,X,g(R,L_1)) - C - \delta K\,] + \mu[z(R) - g(R,L_1)] + \theta h(R,S,\mathbf{x}) \qquad (14)$$

where $X = (L - L_1)$, and λ, μ, and θ are co-state variables. Beside the ordinary transversality conditions, the optimal conditions then becomes

$dH/dC = 0$ or $U_C = \lambda$ (15)

$dH/dL_1 = 0$ or $[f_X - f_g g_{L1}]\lambda + \mu g_{L1} = 0$ (16)

$- dH/dK = d\lambda/dt - r\lambda$ or $r - (d\lambda/dt)/\lambda = i_K = f_K - \delta$ (17)

$- dH/dR = d\mu/dt - r\mu$ or

$r - (d\mu/dt)/\mu = i_R = f_g g_R(\lambda/\mu) + (z_R - g_R) + (\theta/\mu)h_R$ (18)

$- dH/dS = d\theta/dt - r\theta$ or

$r - (d\theta/dt)/\theta = i_S = (U_S/\theta) + h_S$ (19)

Let us now insert these conditions using the procedure described earlier; normalize optimal conditions by dividing by $U_C = \lambda$ to obtain SEK-values, multiply each optimality condition with its "corresponding variable", and – after some re-arranging - then insert them into the SAM. Then linearize the utility function U w.r.t. C before inserting it into the household column in the SAM (to get C in the table). The SAM is now organized so that the LSCVH or NRP appears in the household column.[15]

First, let us take a closer look at the household "income"-row. Recognizing that $i_K = r - (d\lambda/dt)/\lambda$ we reformulate the R- and S-rate of interests, $i_R = r - (d\mu/dt)/\mu$ and $i_S = r - (d\theta/dt)/\theta$, and rewrite $(\mu/\lambda)i_R R$ and $(\theta/\lambda)i_S S$ to become

[15] Note that gf_g and $(\mu/\lambda)z$ are added and subtracted to the R-row.

$$i_K(\mu/\lambda)R - [d(\mu/\lambda)/dt]R + i_K(\theta/\lambda)R - [d(\theta/\lambda)/dt]S + (\mu/\lambda)[z - z_R R]$$

Total income for households in the region is then

$$Ki_K + Lf_X + i_K(\mu/\lambda)R + i_K(\theta/\lambda)S - [d(\mu/\lambda)/dt]R - [d(\theta/\lambda)/dt]S + (\mu/\lambda)[z - z_R R]$$

The first two terms are income from man-made capital and labor. The third and fourth term represent interest rate on natural and cultural capital. The following two terms are capital gains/losses on natural and cultural capital that occurs due to changing stock prices. The last term is profit accruing to the harvesting sector of the economy.

The household column, reduces to

$$C + I - \delta K + (\mu/\lambda)(dR/dt) + (\theta/\lambda)(dS/dt) + (U_S/\lambda)S$$

That is, consumption and net changes in the man-made capital, reindeer and cultural stocks (in monetary terms), plus a term which represent the "consumption" of culture in the economy. This new term can be found in table 3 in the household column (*S*-cell). This is the marginal value of the cultural stock expressed in monetary value. This is the amount of culture "consumed" by households of the economy. If the owners of *S*-capital would be compensated for upholding the cultural stock in each period of time, this would be the amount. We can think of it as if the economy could "pay" the *S*-sector to be able to "consume" a fraction of the cultural stock in each time period. Can we observe such a value or amount in reality? Let us assume that the per kilo subsidy, τ, to the reindeer industry is society's valuation of the Saami culture; a compensation to the cultural sector (*S*-capital) for upholding the Saami cultural heritage. Then society's valuation of the Saami culture in each time period is equivalent to $\tau g(R,L_1)$. The social planner can deduct this amount from the households (see the *S*-cell in household column), and redistribute to the *S*-capital in table 3. If the subsidy is a reflection of the true contribution of cultural capital to the economy (the economy's "consumption of culture), then

$$\tau g(R,L_1) = (U_S/U_C)S$$

and the household column will then reduce to the familiar net regional product measure (NRI)

$$C + I - \delta K + (\mu/\lambda)(dR/dt) + (\theta/\lambda)(dS/dt) + (U_S/\lambda)S - \tau g$$
$$= C + I - \delta K + (\mu/\lambda)(dR/dt) + (\theta/\lambda)(dS/dt)$$

That is, consumption and investment, plus the value of net changes in the natural and cultural stocks.

From table 3, we see that total compensation to the *R*- and *S*-sectors of the economy is

$$g(R,L_1)f_g + \tau g(R,L_1) = (f_g + \tau)g(R,L_1)$$

This implies that the Saami reindeer herders can sell their meat at competitive price f_g and in addition receive a "cultural" per kilo subsidy, τ, which can be interpreted as compensation to owners of cultural capital (owned by those who operate reindeer husbandry).

Table 3. Social accounting matrix (non-renewable resource, *R*-capital, and cultural resource, *S*-capital)

Receipts → Expenditures ↓	Consumption and *K*-investment	K	L	R	S	H
Consumption and *K*-investment						$C + I$
K	Kf_K					$- \delta K$
L	Xf_X					$- g_{L1}(\mu/\lambda - f_g)L_1$
R	gf_g					$- g_R(\mu/\lambda - f_g)R + (\theta/\lambda)h_R R$ $- gf_g + (\mu/\lambda)z$
S	τg					$(U_S/\lambda)S + (\theta/\lambda)h_S S - \tau g$
H		Ki_K	Lf_X	$(\mu/\lambda)i_R R$ $+ (\mu/\lambda)[z - z_R R]$	$(\theta/\lambda)i_S S$	

Conclusion

Measuring welfare and economic development has been occupying economists for many years. As discussed in the literature, simply using some measure of production or some income variable, are rather blunt measurements of welfare. In this paper we discuss how natural and cultural capital can be incorporated in the description of a simple dynamic economy. The main conclusion - as in many other similar studies of economic growth and natural capital – is that the income and production accounts of the economy will be augmented with income flows and the value of net changes of the natural and cultural stocks.

Furthermore, in our analysis of cultural capital, we specifically investigate how to set the "optimal" per kilo meat subsidy to be distributed to reindeer herders to compensate for upholding the Saami cultural heritage. Assuming that the social planner of the economy can identify the value of the cultural stock "consumed" by the economy in each period, the total SEK subsidy should be set so that harvested kilos of meat times the subsidy per kilo is equal to this value. Obviously, identifying the period-to-period consumption of a cultural stock, or even identifying, in monetary or physical terms, the actual stock it self, is quite a complex task indeed. Hence, such a value would have to be approximated using some elaborate decision criteria or simply conjectured.

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