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COST BENEFIT ANALYSIS AND THE SOCIAL TIME PREFERENCE RATE TO ESTIMATE SOCIAL DISCOUNT RATE IN THE CZECH REPUBLIC

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The choice of the discount rate is a crucial issue for evaluating projects with long-term impacts. The paper deals with a calculation of a social discount rate for the Czech Republic based upon the Social Time Preference Rate (STPR), from which perspective the critical components of the STPR are: the elasticity of the marginal utility of consumption, the growth rate of per capita real consumption, and mortality based utility discount rate. Estimates turn out to be 1.36; 2.9 and 1.31 % respectively yielding an overall figure of 5.25 %.

Introduction

Cost-benefit analysis for project and policy evaluation proceeds in two steps. First, one needs to estimate the costs and benefits of a project or policy at each point in

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time. Second, one needs to compare these costs and benefits across time. Time discounting in the public sector remains a source of confusion and some academic controversy. The very concept of a "social" discount rate, not revealed by the market, is rejected by mainstream financial economics. Elsewhere the setting of public sector discount rates equal to the commercial return on private investment continues to have wide appeal. Both these approaches are flawed. More widely favoured by experts in the field today is a rate derived as the sum of pure time preference for marginal utility and a factor reflecting the decline in marginal utility of income as per capita income increases. However, controversy continues about pure time preference, especially in the absence of empirical data on people's social (as opposed to individual) preferences.

Cost-Benefit Analysis

The presence of market failures is usually considered, along with redistribution, as the main rationale for public sector involvement in the economy. For instance, whenever competition is imperfect, production or consumption generate externalities, non-excludability and non-rivalry make impossible or undesirable charging users for the provision of a good, then the government intervention can in principle result in a more efficient allocation of resources thereby potentially enhancing social welfare. When there is a case for public involvement, the costs and the benefits of the envisaged intervention should be carefully identified and compared in order to ascertain whether the latter are likely to outweigh the former. This is the main aim of CBA as an evaluation tool to assist decision-makers to make rational choices about public resources allocation. [1]

CBA is a policy assessment method that quantifies in monetary terms the value of all policy consequences to all members of society. The net social benefits measure the value of the policy. Social benefit (B) minus social costs (C) equal net social benefits. [2]

Social Discount Rate

When evaluating government policies or projects, analysts must decide on the appropriate weights to apply to policy impacts that occur in different year.

The social discount rate, which measures the relative value of communal consumption at different points in time, is one of the most critical parameters in CBA and it is not surprising, therefore, that so much controversy has centred on the concept of social discounting over the years [3].

Different discounting practices by governments have resulted in the application of some widely divergent social discount rates (SDR) across European

countries. In 2002, for example, the French rate, based on the marginal product of capital, was 8% while the German rate, based on recent values of the real long-term government bond rate, was just 3 %. The official rate for the UK, a compromise between cost of capital and time preference considerations, was 6 %. The French government followed suit in 2005 by reducing its official rate to 4 %. There is near convergence now between the official discount rates of three important EU member countries. [4] The Czech Republic has not decided to follow any of existing concepts and usually follows recommended value by the European Commission which does not necessarily have to precise.

A major reason why the quality of CBA varies widely is inconsistent use of the SDR. What is the foundation of a communal rate? There is a long-winded debate in economic literature about this issue. There are, basically, four ideas [5]:

- the market rate of interest;
- the government borrowing rate;
- the social opportunity cost rate (SOCR);
- the social time preference rate (STPR).

Social Time Preference Rate

Long-lived projects typically involve a sacrifice of consumption by the present generation in order to generate benefits for future generations. To decide whether the sacrifice is warranted, society must weigh the current loss in consumption against the future gains. Ramsey, Marglin and Arrow argue that society should treat all generations' welfare equally but should consider that future generations will likely have higher per capita consumption than the current generations due to ongoing economic growth. Consequently, assuming that consumption has declining marginal utility, consumption by a future generation should have a lower weight than consumption by present generations, where the rate at which the weights decline over time is proportional to the growth rate of per capita consumption - the higher the growth rate, the higher the SDR. [2]

The use of STPR as the social discount rate, supported by Marglin, Diamond and Kay, is based on the argument that public projects displace current consumption, and streams of costs and benefits to be discounted are essentially streams of consumption goods either postponed or gained. Two alternative methods have been suggested for empirical estimation of STPR. One is to approximate it by the after-tax rate of return on government bonds or other low-risk marketable securities. The second, more usual, is Ramsey formula.

Definition of Ramsey formula is basically based on CBA outcomes in relation to Social Welfare concept. Primary CBA financial indicator is NPV (Net Present Value). NPV can be defined as [6])

$$NPV = \int_{t=0}^{T} (b_t - c_t) e^{-rt} \mathrm{d}t \tag{1}$$

where b is project benefits, c project costs, r SDR and t time.

For further analysis we assume that at any time t the net benefits from a project $(b_t - c_t)$ are available for consumption (C_t – consumption per capita). Project NPV is then rewritten as

$$NPV = \int_{t=0}^{T} C_t e^{-rt} \mathrm{d}t \tag{2}$$

In equation (2) the discount rate r receives a second interpretation. It is the rate at which the value of a small increment of consumption falls as time changes and, hence, it is called consumption discount rate (CDR). Note now, that the social discount rate — the rate with which we should discount to evaluate a public project — is equal to the consumption discount rate.

To connect NPV with social welfare analysis there can be used additive Paretian social welfare function (W), expressed by integration function or weighting function of consumption in different periods, and consumption growth in one period without fall in other period is considered improvement [7]

$$W = \int_{t=0}^{T} U(t) e^{-\rho t} \mathrm{d}t \tag{3}$$

or

$$W = \frac{U_0}{(1+\rho)^0} + \frac{U_1}{(1+\rho)^1} + \frac{U_T}{(1+\rho)^T} = \sum_{t=0}^{t=T} \frac{U_t}{(1+\rho)^t} \tag{4}$$

where $U(t)$ is a time invariant utility function and ρ is the utility discount rate (UDR). Utility function is defined by the equation

$$U(t) = \frac{C_t^{1-\eta}}{1-\eta} \tag{5}$$

where η ($0 \leq \eta < \infty$) is the elasticity of marginal utility with respect to consumption.

The weight of utility from consumption declines over time with rate ρ. UDR is the rate at which the value of a small increment of consumption falls as time

changes. This brings out clearly that the CDR and UDR are different concepts with a certain relation called Ramsey formula

$$r = \rho + \eta g \tag{6}$$

or

$$r = \rho + \frac{\dot{C}}{C} \tag{7}$$

where g or $\frac{\dot{C}}{C}$ is the growth rate of consumption per capita.

Utility Discount Rate (ρ)

There is a great deal of discussion and controversy over what value(s) ρ should take. It represents the rate at which society discounts future generations' welfare, even if all generations have equal consumption per capita (i.e. $g = 0$). It is usually understood as a concept involving two components [8]

$$\rho = \delta + L \tag{8}$$

where δ is Pure Time Preference Rate – PTPR and L is Changing Life Chance. The first component in formula (8) is δ, reflecting the rate at which individuals discount future consumption over present consumption, on the assumption that no change in per capita consumption is expected [9].

According to Spackman [10] some authors (Ramsey, Pigou, Solow, Kula, Price, Broome and Cline) are of the opinion that $\delta = 0$, for the reason that positive δ gives future generation benefits less value than the current one and such idea consider ethically indefensible. Other authors (e.g., Arrow) object that a zero rate of pure time implies a patently unrealistic level of investment. It implies, regardless of the return on investment (provided the return is positive), a savings rate of 1/η. A plausible value for η of around 1.5 % thus implies a savings rate of about 2/3. [10] This was also Ramsey's original outcome but such savings rate is unacceptable [11].

Official methodical approach in Great Britain [9] and other authors (e.g. Scott) suggest that long-run savings behaviour in the UK is consistent with a value of δ of 0.5 %. This component of the social time preference rate is the least amenable to empirical analysis, but the literature suggests that the range is 0.0-0.5 % [12].

The second component, catastrophe risk (L), is the likelihood that there will be some event so devastating that all returns from policies, programs or projects are eliminated, or at least radically and unpredictably altered. Examples are

technological advancements that lead to premature obsolescence, or natural disasters, major wars, etc. The scale of this risk is, by its nature, hard to quantify [9].

Thus some authors, such as Kula, look at the increasing risk of death for an individual as they get older. While this will certainly be an important risk of death for an individual to favour early consumption over later, it is far from clear what role this should play in discussions about the discount rate. Another Newbery focus on a death rate dividing by the population [8]

$$L = \frac{\text{Total deaths}}{\text{Total population}} \tag{9}$$

Estimates of the parameter ρ differ among authors and depend on the method of calculation. Some studies use decomposition (δ and L), others understand parameter ρ as the whole.

Elasticity of Marginal Utility (η)

The parameter η represents a social evaluation of the intergenerational distribution of income. It summarizes the key value judgment about how quickly the marginal utility of consumption (dU/dC) declines as average consumption rises [2].

We assume a positive but strictly decreasing marginal utility of consumption (diminishing marginal utility). Formally [8]

$$U'(t) = \frac{\mathrm{d}U}{\mathrm{d}C} > 0 \tag{10}$$

but

$$U'' = \frac{\mathrm{d}^2U}{\mathrm{d}C^2} < 0 \tag{11}$$

η then measures the percentage rate at which the marginal utility falls for every percentage increase in consumption. Formally

$$\eta = \frac{U''(t)}{U'(t)}\,C \tag{12}$$

The empirical work on η involves three fundamentally different approaches: direct survey methods, indirect behavioural evidence and revealed social values. For the purpose of this work, method revealed social values will be analyzed and

used for SDR calculation. Although other methods have been used worldwide to calculate η, revealed social values have been found by the authors the most understandable and easy to apply in practice.

A suitable value for η may be revealed through government spending or tax policies. For example, the extent of progressiveness in a country's personal income tax rates can be viewed as a reflection of the government's degree of aversion to income inequality (a measure of η). According to Evans [13] Stern, Cowell and Gardiner have produced estimates of η for the UK using personal income tax data. In both cases, the tax structure is assumed to be based on the principle of "equal absolute sacrifice of satisfaction" and, in common with most researchers, iso-elastic utility functions are assumed. The model is set out formally below [13]

$$U(Y_t) - U(Y_t - T(Y_t)) = K \tag{13}$$

where $T(Y_t)$ is the income tax function reflecting the tax liabilities of and individual, K is the constant and Y_t taxable income.

Furthermore, if utility functions are typically iso-elastic, then

$$\frac{Y_t^{1-\eta}}{1-\eta} - \frac{Y_t - T(Y)^{1-\eta}}{1-\eta} = K \tag{14}$$

Taking the total differential and logs of equation gives

$$\eta = \frac{\ln\left(1 - \dfrac{\partial T(Y_1)}{\partial Y_1}\right)}{\ln\left(1 - \dfrac{T(Y_1)}{Y_1}\right)} = \frac{\ln(1-t)}{\ln\left(1 - \dfrac{T(Y_1)}{Y_1}\right)} \tag{15}$$

where t is the marginal tax rate and $T(Y_t)/Y$ is the average rate of income tax.

Strengths of this approach are its conceptual simplicity and measurability, and that it may also include concern about fairness as well as marginal utility; but it has two evident limitations. The first comes from the idea that social concern about contemporary inequality might differ from that about inequality over time [10]. The second concerns the fact that de jure statutory tax rates may be quite different from de facto paid tax rates. This is likely to be the case in countries where tax evasion is a serious issue, particularly if individuals with different income levels have different chances to evade [14].

Other problem is when tax system is reformed too often and makes a calculation of η more complicated for the reason of insufficiency of exact date in a row in the timeline. For example, Czech tax reform held in 2008 brought to an existence so called "super gross wage" which will influence a calculation of marginal tax rate and make remarkable modification in calculation necessary.

Annual Rate of Per Capita Real Consumption Growth (g)

It is not easy to predict an annual economic growth for period of 20 and more years for any country. It is possible to base this prediction on the real economic growth involving enough data to involve as many as middle-term economic cycles as possible. Such analyses might be then a basis for a reasonable method of an annual real consumption per capita rate tendency.

To estimate values of g, regression analysis is an ideal tool

$$\ln C_t = B + gt \tag{16}$$

where C_t is real per capita consumption growth in t year, t is years and B constant. A result of the regression analysis is a value g and a correlation coefficient or an index of determination in the case of non-linear trends.

SDR Estimate for the Czech Republic

A calculation of ρ is based on formula (8) and as such will be understood as a sum of two components, δ and L. Estimate of δ will be taken from the literature in the amount of 0.25 as the middle value of the most common interval. According to the Czech Statistical Office a death rate between 1997 and 2007 amounted to 10.6 (per 1.000 persons), i.e. $L = 1.06$. Based on formula (8), $\rho = 1.31$.

Parameter η will be calculated using Revealed Social Value method for its data availability and possibility to compare results with European Commission official recommendations coming from this approach as well. According to the OECD statistics in the Czech Republic:

a) average wage was 250 262 CZK;
b) annual taxable income (Y_t) was 218 979 CZK;
c) the income tax: $T(Y_t)$ was 33 157 CZK.

Annual taxable income slightly exceed an interval (121 200-218 400 CZK) for the marginal tax rate 20 % and therefore this rate can be regarded as t. Using formula (15), η amounted to 1.36. This value reaches average value estimate 1.35 by Evans [4] for 20 OECD countries including the Czech Republic for which the

interval was set to 1.22-1.36.

The Czech economy underwent a dynamic transformation period from the beginning of the nineties. Due to this process there is not a sufficiency of relevant data of a consumption development as in many other countries especially in the EU-15. Formula (16) will be used to estimate parameter g, because it better represent a trend and straightens variations than evolution or a division between logarithms of the last and first value of population consumption. A referential period is 13 years, 1995-2007. A coefficient of correlation R^2 amounted to 0.9536 and shows a strong linear trend. A value of parameter g got from the regression at value of 2.9 % can be considered (in respect to a quality of disposable data) relevant, see Fig. 1.

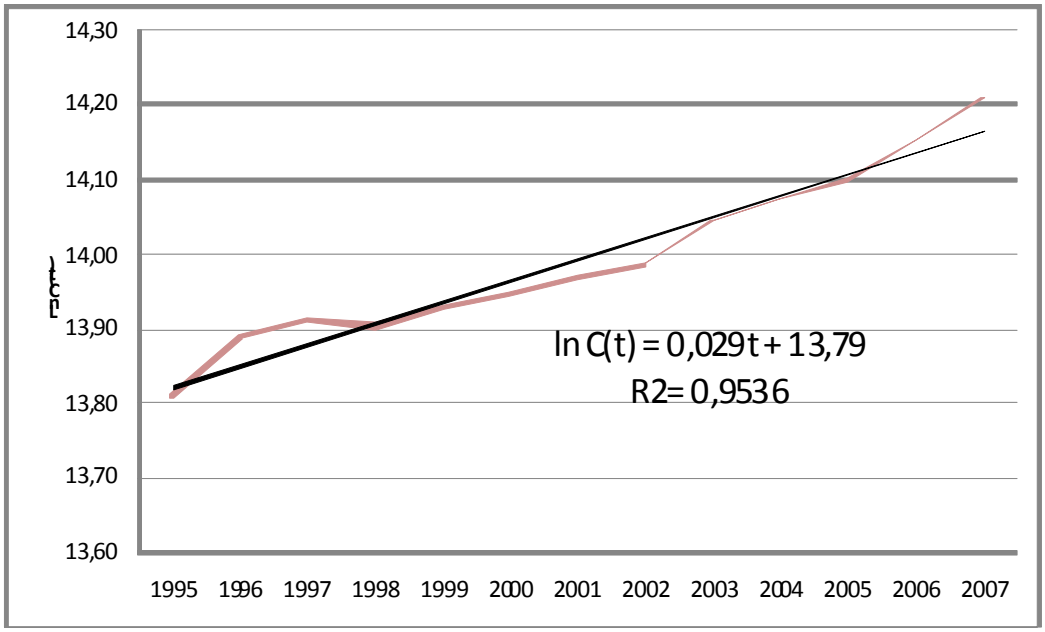

Fig. 1 Calculation of the g parameter with linear regression method

Based on formula (6): $r = 1.31 + 1.36 \times 2.9 = 5.254$, i.e. 5.25 %

Social discount rate for the Czech Republic based on STPR approach, Optimal Growth Rate model and method of Revealed Social Values for the η estimate (2006 data) was estimated as 5.25 %.

Conclusion

The choice of the social discount rate plays a critical role in cost-benefit analysis and project evaluation, and has been a subject of intense debate for the last several decades. In a perfectly competitive world without market distortions, the market interest rate is the appropriate SDR. In the real world where markets are distorted, there are at least four alternative approaches in the choice of the SDR. Economists

have not reached a consensus as to which is the most appropriate.

This work focused on STPR approach. That is because the European Commission put an emphasis on this method in the process of evaluation when subjects of public and private sector apply for the EU funds financial support. As the major components of the STPR were indentified: the utility discount rate (applied a risk of death indicator to estimate parameter *L*), the elasticity of the marginal utility of consumption (applied Reveal Social Value method), and the growth rate of per capita real consumption (applied regression analysis on the 13 years referential period). Final estimates turn out to be 1.31; 1.36 and 2.9 % with overall figure of 5.25 %.

SDR 5.25 % is much closer to recent studies of SDR in the EU and is supported by the European Commission recommendation.

References

[1] Mairate A., Angelini F.: *Cost-Benefit Analysis and EU Cohesion Policy* [online], [cit.: 2010-28-06], available at URL: <http://www.economia.unimi.it/uploads/wp/MAIRATEANGELINI2006_34.pdf>.

[2] Boardman A., Greensberg D.H., Vining A.R., Weimer D.L.: *Cost-Benefit Analysis: Concept and Practice*, 2nd edition, Prentice Hall, New Jersey, 2001.

[3] Kula E.: *Regional Welfare Weights in Investment Appraisal – The Case of India* [online], [cit.: 2009-03-17], available at URL: <http://www.jrap-journal.org/pastvolumes/2000/v32/32-1-6.pdf>.

[4] Evans D.J.: Fiscal Studies **26**, 197 (2005).

[5] Kula E.: *Social Discount Rate in Cost-Benefit Analysis* [online], [cit.: 2008-10-02], available at URL: <http://www.economia.unimi.it/uploads/wp/KULA-2006_19.pdf>.

[6] Zhung J., Liang Z., Lin T., Guzman F.: *Theory and Practice in the Choice of Social Discount Rate for Cost-Benefit Analysis: A Survey*, Asian Development Bank, Manila, 2007.

[7] Creedy J., Guest R.: The Economic Record **84**, 109 (2008).

[8] Pearce D., Ulph D.: *A Social Discount Rate for the United Kingdom*, CSERGE, Norwich, 1995.

[9] HM Treasury: *The Green Book – Appraisal and Evaluation in Central Government* [online], [cit.: 2007-03-24], available at URL: <http://greenbook.treasury.gov.uk/index_terms.htm>.

[10] Spackman M.: *Social Discount Rates for the European Union: An Overview* [online], [cit.: 2009-15-02], available at URL: <http://www.economia.unimi.it>.

[11] Arrow K.: *Intergenerational Equity and the Rate of Discount in Long-Term Social Investment*, IEA, Stanford, 1995.
[12] Oxford Economic Research Associates: *A Social Time Preference Rate for Use in Long-Term Discounting*, Oxford Economic Research Associates, Oxford, 2002.
[13] Evans D.J.: Social Discount Rate for the European Union [online], [cit.: 2010-02-14], available at URL: <http://www.economia.unimi.it/uploads/wp/EVANS-2006_20.pdf>.
[14] Lopez H.: *The Social Discount rate. Estimates for Nine Latin American Countries* [online], [cit.: 2010-15-04], available at URL: <http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2008/06/03/000158349_20080603084938/Rendered/PDF/wps4639.pdf>.