Wellbeing and productivity

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ABSTRACT

In the widely used capital stocks approach to conceptualising intergenerational wellbeing, the wellbeing of the current generation is considered a function of four key capital stocks: produced capital, human capital (labour), social capital, and natural capital. Most discussion of the sustainability of levels of wellbeing into the future is focused on considering whether the quantity of these capital stocks left for future generations will be the same, larger, or smaller than the quantity available to the current generation (e.g., Arrow et al, 2012; OECD, 2013, 2015; Treasury, 2018; Smith, 2018). However, the efficiency with which the capital stocks are used to produce wellbeing also matters. Because the capital stocks approach is grounded in a framework with strong parallels to that underpinning growth accounting, tfp (tfp) provides a potentially useful way of examining this issue.

This article explores the relationship between wellbeing and tfp. An econometric (regression residual) approach is then used to develop methodologically comparable estimates of traditional tfp (where the output in question is national income) and total wellbeing productivity (twp, where the output is mean national life satisfaction). The differences between the two measures are compared and the impact on this of confounding factors – including the roles of social capital, natural capital, and cultural bias in responses to subjective wellbeing measures – is explored. Understanding whether cross-country differences in wellbeing are driven by different factor endowments (the capital stocks) or differences in how efficiently these endowments are used (wtfp) has significant policy implications both for evaluating nations' progress and for identifying what can be done to improve wellbeing.

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1. INTRODUCTION

Human wellbeing is one of the primary goals of public policy. This is reflected in the conceptual framework of standard neo-classical economic analysis which is centred on utility maximisation. However, in practice economic analysis has traditionally focused on income as the primary policy-relevant outcome. This reflects the obvious importance of consumption – and hence income – to human wellbeing as well as the conceptual and technical issues associated with measuring wellbeing in practice. However, in the last 20 years significant progress has been made in the measurement of wellbeing. The ability to directly measure wellbeing opens the door to investigating whether the use of wellbeing as opposed to income as the focus for analysis would lead to substantially different policy judgements.

Key developments in the conceptualisation and measurement of wellbeing over the last 20 years have come from two directions. On the one hand there is a growing body of literature focusing on the measurement of subjective wellbeing and the use of such measures as a proxy for utility in an economic context (Kahnemn, Diener, and Schwarz, 1999; OECD, 2013a, Frijters, Clark, Krekel, and Layard, 2020). Much of this literature is grounded firmly in the utilitarian tradition and sees wellbeing as something fundamentally experienced in the mind. The other main tradition is grounded in the work of Sen and focuses on wellbeing as the ability of a person to live the kind of life they have reason to value (Sen, 1993). This approach conceptualises wellbeing as comprising a vector of distinct capabilities that collectively describe a multi-dimensional frontier within which an individual is able to function.

In principle, these two approaches to wellbeing are quite distinct. Sen, in particular, argues that a person living in heavily constrained circumstances has a low level of wellbeing regardless of their subjective state of mind. In practice, however, the distinction between the neo-utilitarian and the capabilities approach to wellbeing is much less clear. The *Report of the Committee on the Measurement of Economic Performance and Social Progress* (Stiglitz, Sen, Fitoussi, 2009) identifies the of subjective wellbeing as an important capability in its own right, suggesting that the distinction between the two approaches is not absolute. Perhaps more importantly, it is clear that some evaluative measures of subjective wellbeing – such as measures of overall life satisfaction – function as summary measures capturing the impact of the most commonly identified capabilities (Boarini et al, 2013).

Perhaps most importantly, following the release of the Sen/Stiglitz/Fitoussi report a widely used framework for conceptualising and measuring intergenerational wellbeing has emerged (OECD, 2011; Arrow et al, 2012; UNECE, 2014). This framework – often referred to as the capital stocks model – draws on the approach to measuring the current wellbeing of people outlined in Sen, Stiglitz, and Fitoussi (2009) but places this in a coherent economic framework where current wellbeing draws on stocks of productive resources (the capital stocks). Typically four capital stocks are identified: produced capital, human capital, social capital and natural capital. The flow of resources from the capital stocks can either be used for current consumption (wellbeing) or re-invested in the capital stocks. An attractive feature of this approach is that a definition of sustainable development falls directly out of the framework that is consistent with the Brundtland declaration on sustainable development (Butlin, 1989):

> *sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs*

In terms of the capital stocks framework, a sustainable level of wellbeing is defined as one where capital stocks do not decrease over time (Arrow et al, 2012). This can be considered either in terms of soft sustainability (where the total value of the four capital stocks does not decrease over time) or hard sustainability which requires than none of the four capital stocks is allowed to decrease.

Since 2000 an extensive literature has emerged on the determinants of current wellbeing, often focused on the use of an over-arching measure of subjective wellbeing such as life satisfaction (Boarini et al, 2012; Helliwell, Huang and Wang, 2015; Clark et al, 2018). However, far less attention has been paid to the capital stocks. The most substantive contributions on this front have been from the OECD as part of its Better Life Initiative (in particular, see OECD, 2013b, ch 6; and OECD, 2015, ch 3) and Arrow et al (2012). Where capital stocks have been considered the focus has been entirely on the levels of the capital stocks rather than how efficiently they are used (e.g. OECD, 2015).

The lack of investigation into the efficiency with which the capital stocks are used to produce wellbeing represents an important theoretical and empirical gap in the literature. Assuming that the size of the capital stocks and the size of the population whose wellbeing they need to support are held constant, the Brundtland definition of sustainable development necessarily requires an improvement in the efficiency with which the capital stocks are used if there is to be an increase in sustainable wellbeing. Put simply, the wellbeing productivity of the economy matters.

This paper presents an initial exploration of wellbeing productivity and its relationship to more conventional productivity measures. The paper first describes the capital stocks model of intergenerational wellbeing and defines wellbeing total factor productivity (wtfp) in this context. An extended Swann-Solow growth model is used to place the capital stocks model of wellbeing on a clear conceptual basis and a formal definition of wtfp is derived. On the basis of this, an empirical strategy to estimate wtfp is proposed and a series of testable hypotheses about the wellbeing production function and its relation to the four capital stocks are explored.

Section four of the paper describes the dataset used to estimate wtfp and explore its relationship to more conventional productivity measures. This draws on data from the European Social Survey (ESS) on wellbeing and cross-country economic statistics from the Penn World Tables. Information from the FAO land cover database is used to capture variation in natural capital per capita while the Corruption Perceptions Index from Transparency International is used as a measure of social capital. The empirical results are discussed in section five.

The final section of the paper considers the implications of the main empirical findings. Understanding whether cross-country differences in wellbeing are driven by different factor endowments (the capital stocks) or differences in how efficiently these endowments are used (wtfp) has significant policy implications both for evaluating nations' progress and for identifying what can be done to improve wellbeing.

2. CONCEPTUAL FRAMEWORK

The capital stocks framework is the dominant analytical model used in wellbeing economics used for thinking about intergenerational wellbeing and sustainability. However, because the measurement of wellbeing has been the primary focus of wellbeing economics for most of the period from 2000 to 2020 there has been relatively little development of the capital stocks model beyond the level of a measurement framework. This is reasonable as any empirical analysis of the capital stocks model is dependent on the ability to measure wellbeing. However, with the emergence of a coherent approach to the measurement of wellbeing over the last decade, it is possible to look at issues relating to the relationship between the capital stocks and wellbeing.

Before proceeding to outline the model that will be applied to examine wtfp, it is useful to review the main approaches to conceptualising and measuring wellbeing. The economic literature on wellbeing identifies two main approaches[1]. The first of these is the so-called capabilities approach (Sen, 1993),

[1] In addition to the two approaches that form the focus for the economic literature, a third approach to wellbeing can be identified in the public health/medical literature. This approach identifies wellbeing as "wellness" conceived of as positive health states (Roscoe, 2009). Compared to the economic approaches that form the focus of this chapter the wellness literature has a narrower focus. Consider that health is commonly identified as a core capability within Sen's approach to wellbeing and is an major empirical driver of subjective wellbeing,

while the second is the neo-utilitarian or subjective wellbeing approach (Frijters et al, 2020).

Sen (1999) defines wellbeing as the ability to "lead the kinds of lives they value – and have reason to value". In taking this approach Sen grounds wellbeing in a liberal framework that prioritises of (reasoned) individual choice over other values. Wellbeing in this sense, Sen argues, can be conceptualised as a set of capabilities that collectively define a multi-dimensional consumption possibility frontier for each person. Within this framework command over market goods and services – measured by income – is clearly one important dimension of a person's capabilities. However, non-market outcomes such as health status or knowledge and skills also represent important capabilities in that they limit the range of desired functionings that a person can achieve and cannot easily be purchased directly.

The capabilities approach is widely used in government and related policy contexts (e.g. OECD, 2011) for two reasons. First, the capabilities approach is consistent with the standard neo-classical economic framework of ordinal utility and thus integrates easily into conventional policy frameworks. In addition, the multi-dimensional nature of the capabilities framework and the strongly liberal framing of the capabilities approach allows for wellbeing indicators to be presented in a "dashboard" without the introduction of strong – and potentially contentious – assumptions about the relative importance of different outcomes.

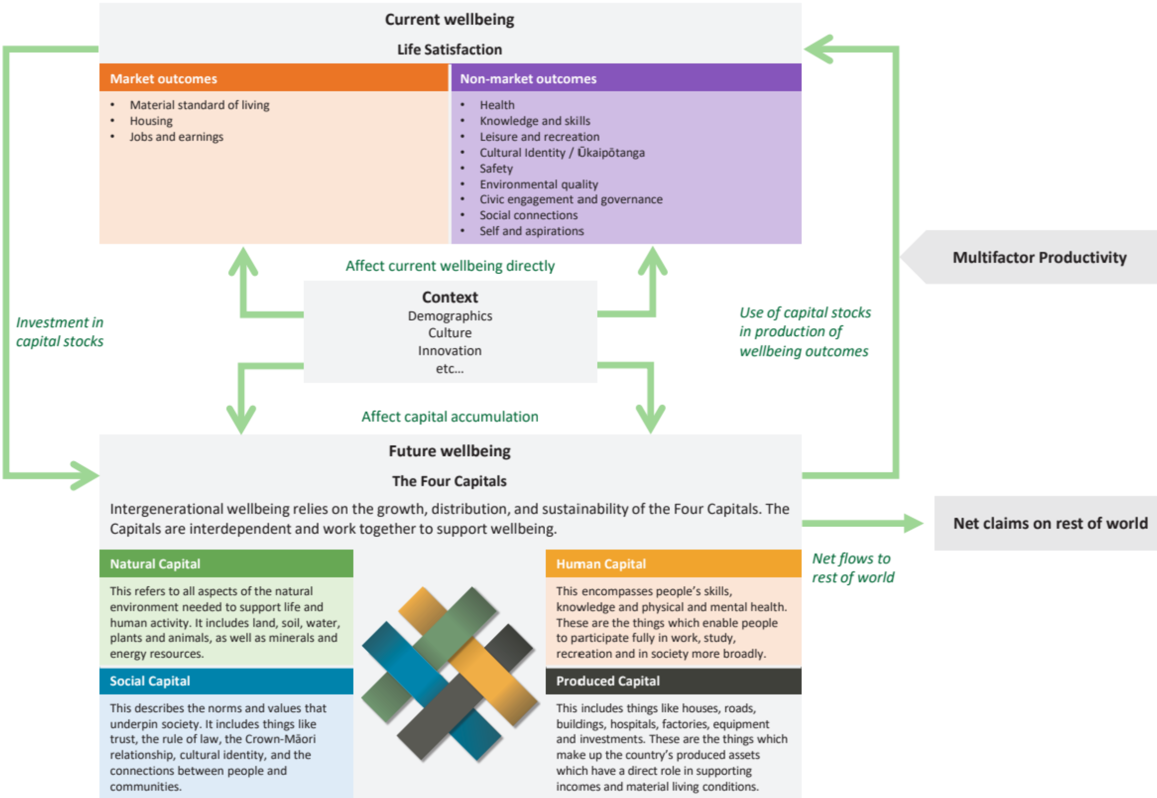
The main alternative to the capabilities approach is the neo-utilitarian conception of wellbeing. Building on significant evidence that measures of subjective wellbeing are meaningful and valid (OECD, 2013a) this approach frames wellbeing in terms of subjective mental states. Fundamentally, a person is deemed to have high wellbeing if they experience positive mental states. In contrast to the multi-dimensional indicator dashboards used to measure wellbeing under the capabilities approach, the neo-utilitarian approach tends to focus on the use of a single over-arching measure of subjective wellbeing. The most commonly used such measure is overall satisfaction with life or a similar evaluative measure (OECD, 2013a).

In principle the capabilities approach and the neo-utilitarian approach are incompatible. Sen (1993) explicitly considers the situation where a person living in degrading poverty is subjectively happy with their life and accepts their state because they have no basis for comparison. Despite being satisfied with their life, Sen argues that such a person would have low wellbeing. In practice, however, it is less clear that there is a significant mismatch between the two approaches. In particular, while it is easy to present illustrative examples where the two approaches to wellbeing might yield different judgements, the empirical evidence suggests very strongly that people with limited capabilities also tend to report low levels of subjective wellbeing (Helliwell, Huang, Wang, 2015). Similarly, analysis of the main determinants of subjective wellbeing shows that these are very similar to commonly cited lists of important capabilities (Boarini et al, 2012).

The capital stocks framework builds on the measurement of wellbeing by placing wellbeing in an explicitly inter-temporal context and linking wellbeing as an outcome with the resources required to produce wellbeing. In effect, the capital stocks model links consumption and the utility function on the one hand (wellbeing) with production on the other (the capital stocks). Figure 1 below is taken from a report prepared for the New Zealand Treasury (Smith, 2018) and represents the capital stock framework as a diagram. This particular diagram is used because it is relatively simple and it clearly identifies the nature of the resource flows in the model in terms of production and investment, but is fundamentally the same as diagrams of the capital stocks framework from the OECD (2011, 2013b, 2015), Arrow et al (2012), Costanza et al (2016) and others.

thus making health a sub-dimension or driver of wellbeing within the economic approach. In contrast, the "wellness" approach sees wellbeing as an element of health.

Figure 1. The capital stocks framework



It is clear from figure 1 that the capital stocks model can be thought of in terms of production and consumption. The four capital stocks (natural capital, social capital, human capital, and produced capital) function as factors of production that are combined to produce a range of outputs that either directly contribute to wellbeing (market and non-market outcomes) or which are invested in maintaining the level of the capital stocks. Conceptually, this framework can be seen as an extended version of a Solow-Swann growth model (Solow, 1956; Swann, 1956). This is reflected both in an implicit production function involving the four capital stocks and a decision about the investment rate that determines the maximum sustainable level of market and non-market consumption (and therefore wellbeing).

While viewing the capital stocks framework through the lens of a Solow-Swann growth model represents a ruthless simplification of a complex issue, such an approach also has significant advantages. In particular, it provides a framework for examining the relationship between the capital stocks and wellbeing in empirical terms. In contrast to the extensive literature on the measurement of wellbeing and the determinants of wellbeing at an individual level, there is comparatively little empirical literature focusing on the relationship between the capital stocks and wellbeing, and even less that considers this from the perspective of productivity.

Engelbrecht (2015) explores the contribution of both social and natural capital to wellbeing and finds a significant relationship in both cases. However, the approach adopted by Engelbrecht is simply a cross country wellbeing regression and there is no attempt to situate the capital stocks within a formal framework distinguishing between the production function and the utility function. Another empirical examination of the relationship between wellbeing and the capital stocks is Qassim and Grimes (2021), who consider how the relationship between genuine savings and wellbeing varies in the short and long run. They find support for the capital stocks model in that genuine savings is negatively related to wellbeing in the short run but has a positive correlation in the long run. This is consistent with the capital stocks model in that there is a trade-off between savings and consumption in the short run, but in the long a higher genuine savings rate implies greater investment in the capital stocks and higher future consumption.

One of the few papers that does investigate the capital stocks model from an empirical perspective, and which also discusses the impact of tfp in this context is Arrow et al (2012). However, the focus of Arrow et al is to define comprehensive wealth (the discounted present value of the capital stocks) rather than to investigate the relationship between the capital stocks and wellbeing. Consequently, while a conventional measure of tfp is incorporated into their model, Arrow et al do not investigate productivity from the perspective of the efficiency with which the capital stocks contribute to overall wellbeing. It is, however, precisely this issue that is the focus of this paper.

3. METHOD

To begin with it is necessary to provide a definition of wellbeing. Consider the following utility function:

1) $U = f(C, Y)$

where Y is income and C is a vector of non-market outcomes important to a person's wellbeing. If we are willing to accept a measure of subjective wellbeing, such as life satisfaction, as a (possibly noisy) proxy for utility then it is possible to empirically estimate a utility function as follows:

2) $W_i = \beta_0 + \beta_1 C_i + \beta_2 \ln(Y_i) + \varepsilon$

In this equation W_i is the life satisfaction (wellbeing) of person i, C_i is a vector of non-market drivers of life satisfaction (e.g. health status, knowledge and skills, safety) experienced by person i and Y_i is the income of person i. Note that life satisfaction is a bounded measure (typically from 0 to 10) while income is unbounded on the upward side. This imposes the log-linear relationship between life satisfaction and income in equation (2) and is widely supported empirically (e.g. Deaton, 2008; Sacks, Stevenson, and Wolfers, 2012). In contrast, C_i is assumed to have a linear relationship with life satisfaction since most of the non-market outcome measures typically included in regressions of this type (e.g. Boarini et al, 2013), are bounded themselves.

To incorporate the capital stocks into the model it is necessary to set out an approach to production. The simplest way to approach this is simply to consider wellbeing as the single output of an aggregate production function. Equation (3) below sets out this approach where W_c is mean life satisfaction of country c, $\widetilde{A_c}$ is wtfp for country c, K_c is the per capita (produced) capital stock of country c, and L_c is the per capita human capital stock of country c which is assumed to be a function of the labour utilisation rate and the mean level of education.

3) $W_c = \widetilde{A}_c K_c^{\rho_1} L_c^{\rho_2}$

While something like equation (3) is implicit in the capital stocks model, this very reduced form approach fails to take the utility function seriously and is difficult to decompose in any useful way to provide an insight into what drives the underlying relationships. An alternative – or possibly complementary approach – is to consider the market and non-market contributions to wellbeing separately. Equations (4) and (5) below specify respectively an aggregate production function for market goods, which we can assess through income (Y) and a similar production function for non-market goods.

4) $Y_c = A_c K_c^{\alpha_1} L_c^{\alpha_2}$

5) $C_c = \ln(a_c K_c^{\gamma_1} L_c^{\gamma_2})$

Equation (4) is relatively straight forward, with A_c being the tfp of country c, Y_c being per capita income of country c, K_c and L_c capture produced and human capital as in equation (3). Note that this is the standard growth accounting aggregate production function and can be used to estimate tfp. Non-market production – equation (5) – is similar, with a_c being the non-market tfp of country c and C_c being a vector of mean non-market outcomes for country c. For simplicity it is assumed that the production of non-market outcomes and market outcomes is non-rival in terms of K and L[2].

Given information on Y_c, K_c, and L_c it is possible to estimate α_1, α_2, and A_c, capturing the elasticity of output with respect to produced and human capital respectively and tfp. Taking the log of equation (4) we can estimate the relationship as model (6):

6) $\ln(Y_c) = \ln(A_c) + \alpha_1 \ln(K_c) + \alpha_2 \ln(L_c) + \varepsilon$

Solving equation (6) for A_c is trivial and gives an estimate of tfp as the Solow-Swann residual. While this is not the preferred approach to estimating tfp in most circumstances, it has the appeal here that a similar approach can potentially be applied to equation (5). Estimating A_c and a_c using the same method in turn allows for a comparison between the two measures of productivity without bias introduced due to method effects.

Estimating equation (5) is a little more involved than is the case for equation (4). In particular, we lack a definitive list of non-market outcomes and, even were such a list available, there is no common metric on which we could assess them. Rather than estimating equation (5) directly, it is therefore necessary to approach the issue via measures of overall wellbeing. Equation (7) below presents the country level equivalent of equation (2):

7) $W_c = \beta_0 + \theta_c + \beta_1 C_c + \beta_2 \ln(Y_c) + \varepsilon$

All variables in equation 6 are country means. The constant θ_c has been introduced to capture cultural response bias that might introduce non-random measurement error across countries. Rearranging (7) we can define $\widehat{W_c}$ as non-market variance in life satisfaction as follows:

8) $\widehat{W_c} = W_c - \beta_0 - \beta_2 \ln(Y_c)$

If we then substitute in equation (4) then gives the following identity (9):

9) $\widehat{W_c} = \theta_c + \beta_1 C_c = \theta_c + \beta_1 \ln(a_c K_c^{\gamma_1} L_c^{\gamma_2})$

If a credible control for cultural response bias in life satisfaction can be identified, it is then possible to estimate non-market tfp directly as follows:

10) $\widehat{W_c} - \theta_c = \beta_1 a_c + \beta_1 \gamma_1 \ln(K_c) + \beta_1 \gamma_2 \ln(L_c) + \varepsilon$

If equation (10) is estimated empirically, we cannot observe γ_1 and γ_2 directly as the coefficients on produced capital per capita and human capital per capita will be $\beta_1\gamma_1$ and $\beta_1\gamma_2$. However, the ratio of the two coefficients $\frac{\beta_1\gamma_1}{\beta_1\gamma_2}$ can be compared directly to the ratio of the two elasticities from equation (5): $\frac{\alpha_1}{\alpha_2}$. Similarly, the residual estimate of tfp from equation (9) will be a linear transformation of actual tfp (i.e. we observe $\beta_1 a_c$ rather than a_c). This is sufficient to identify countries where market tfp and non-market tfp differ.

Empirically estimating the model in equation (9) requires, in addition to the underlying data, good estimates of β_2 (the income coefficient on life satisfaction) and θ_c (cultural response bias in life satisfaction). The former is easy to obtain and can be estimated directly form a cross-country life satisfaction regression along the lines of that presented in equation (7) or taken directly from the substantial existing academic literature (e.g. Sacks, Stevenson, and Wolfers, 2012). Cultural response bias, on the other hand, is more difficult to estimate.

The key challenge in estimating cultural response bias is that it is difficult to distinguish between cultural response bias (a measurement error that should be corrected for) and genuine cultural impacts on

[2] In reality, some aspects of the capital stocks will be non-rival and others will be rival. The issue of allocating capital across the non-market and market sectors is left for further work. It should be noted, however, that conceptually the assumption that market and non-market goods are non-rival between equations (3) and (4) is not different to the assumption that the issue of rival uses of capital can be ignored within the equation (3) on its own (i.e. between different market goods).

wellbeing or omitted variables affecting life satisfaction (both of which should not be corrected for). A number of approaches have been proposed to identify cultural response bias including the use of anchoring vignettes (Van Soest et al, 2010) and leveraging differences between country of birth and country of residence (Senik, 2014; Exton, Smith, and Vandendreische, 2015). While vignettes require extensive data collection, it is possible to estimate a value for θ_c from any dataset with information on life satisfaction, country of residence and country of birth. The simplest approach[3] to this is as follows:

11) $= W_{i,r,b} = \beta_0 + \beta_1 D_i + \theta_b + \mu_r + \varepsilon$

In equation (11) $W_{i,r,b}$ is the life satisfaction of individual i residing in country r and born in country b while D_i is a vector of demographic controls Finally, θ_b and μ_r are vectors of dummy variables for country of residence and country of birth each having a value of 0 for all countries except for those where the respondent was born and currently resides. From this regression we can interpret θ_b as the impact of having been born in a specific country independently of the impact of current influences on life satisfaction from where one lives (μ_r). Thus θ_b captures the impact of residual social ties to one's country of birth as well as the impact of culture on life satisfaction responses.

The approach presented above in equations (4) to (10) breaks wtfp down into two elements: market and non-market. This is useful to understand why countries differ in wellbeing and the relative roles of productivity and the capital stocks in explaining cross-country variation in wellbeing. Importantly, this provides a framework for empirically assessing aspects of the capital stocks model. In particular, there are three key relationships to be tested:

I. If the capital stocks are not important drivers of non-market outcomes (i.e. $\beta_1\gamma_1$ = 0 or $\beta_1\gamma_2$ = 0) then the capital stocks model is fundamentally broken
II. We can also compare whether the role of the capital stocks in producing non-market outcomes is similar to that for market outcomes (i.e. test whether $\frac{\beta_1\gamma_1}{\beta_1\gamma_2} = \frac{\alpha_1}{\alpha_2}$)
III. Finally, it is interesting to see whether the relationship between tfp for market outcomes is similar to that for non-market outcomes (i.e. is there a consistent linear relationship between A_c and a_c).

The models discussed above focus on developing an estimate of non-market productivity comparable to traditional estimates of tfp. However, the capital stocks model of wellbeing usually incorporates four different capital stocks rather than just two: produced capital, human capital, natural capital, and social capital. If measures of natural capital and social capital are available, extending equations (3), (4) and (5) to include the full range of capitals in the capital stocks model is straight forward. If S_c is a measure of country-level social capital, such as generalised trust (Smith, 2020), and natural capital is a measure of the overall stock of natural capital then:

12) $W_c = \widetilde{A_c} K_c^{\rho_1} L_c^{\rho_2} N_c^{\rho_3} S_c^{\rho_4}$

13) $Y_c = A_c K_c^{\alpha_1} L_c^{\alpha_2} N_c^{\alpha_3} S_c^{\alpha_4}$

14) $C_c = \ln(a_c K_c^{\gamma_1} L_c^{\gamma_2} N_c^{\gamma_3} S_c^{\gamma_4})$

This extension of the model allows testing the significance of social and natural capital and the impact of their inclusion in the model on the coefficients for produced capital and human capital.

4) Data

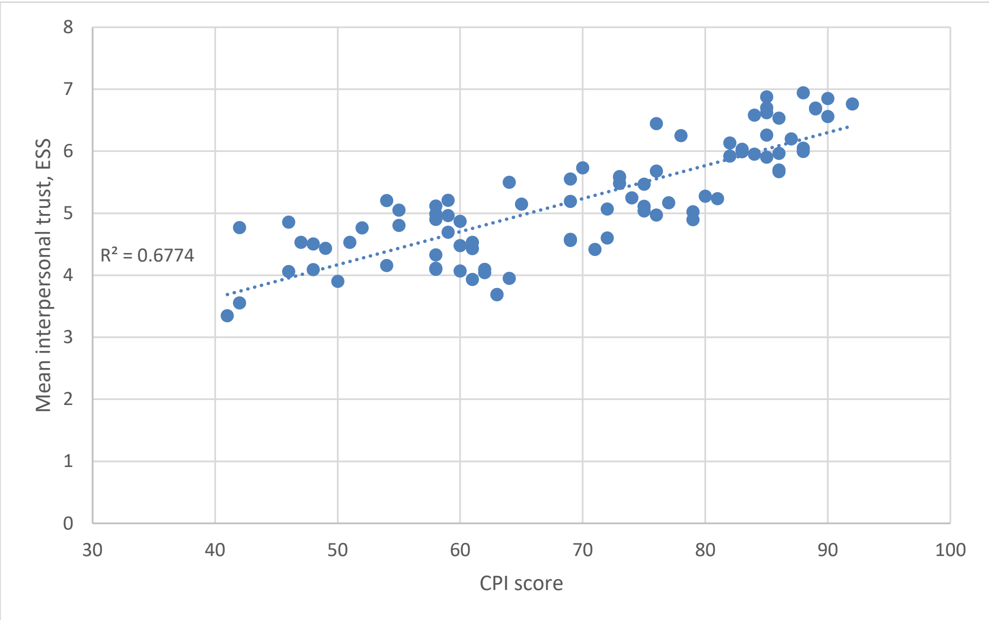
Four data sources are used in the empirical section of this paper. These are the European Social Survey (ESS), the Penn World Tables, the Corruption Perceptions Index, and landcover information from the FAO. Information on life satisfaction and trust is provided by the ESS. The ESS is a two-yearly survey of

[3] Adopting a more sophisticated approach to estimating cultural response bias by following Senik (2012) more closely is an obvious extension to this article.

attitudes, values, and beliefs run across 38 countries in Europe since 2002. Using the ESS cumulative dataset gives information on 9 waves of the survey covering 2002 to 2018 and 427,656 valid responses. This information is collapsed to produce a cross-country panel dataset containing the mean life satisfaction and mean generalised trust score for each country and survey wave. Individual level data from the ESS is also used to provide an estimate of cultural response bias.

While interpersonal trust is, perhaps, the best single measure of social capital (Smith, 2020) in the sense in which it is used in the capital stocks model (i.e. as a productive resource), there is a risk that the correlation between interpersonal trust and life satisfaction at the country level might be biased due to shared method variance (OECD, 2013a). The Corruption Perceptions Index is a composite indicator of public sector corruption produced by Transparency International. It covers 180 countries and is comparable for time series purposes from 2012 onwards. Sources for the Corruption Perceptions Index come from 13 different surveys and expert assessments (Transparency International, 2020). Importantly, these assessments are external to the countries under evaluation meaning that – unlike the ESS trust measure – there is no risk of correlation with life satisfaction due to survey effects or cultural response bias. However, as illustrated in figure 2 below, the Corruption Perceptions Index is strongly correlated with generalised trust across countries. On this basis the Corruption Perceptions Index is used as a proxy measure of social capital in the growth regressions that form the core of this paper.

Figure 2. Cross-country dataset



Information on GDP, produced capital, human capital, and market tfp was obtained from the Penn World Tables (Feenstra, Inklaar, and Timmer, 2015), covering the same period as for the ESS. Although estimates of tfp in the next section are derived directly from the Solow-Swann residual, the Penn World Table measure of tfp provides a useful validity check to ensure that the cruder approach required here for consistency with the wtfp measures is not introducing any systematic bias.

Table 1 below presents the variables used in the analysis along with basic descriptive information. Real GDP per capita is output GDP at constant prices (PPP) across countries deflated against the USA 2017 and divided by population. Following Inklaar, Woltjer, Albarrán and Gallardo (2019), the capital services measure from the PWT divided by population is used for produced capital per capita (K_c). Human capital per capita is an index calculated as persons engaged in the labour market multiplied by average hours worked multiplied by the PWT human capital index divided by population.

Wilderness area per capita is the area in hectares of landcover classifications water, alpine, mangroves, shrubs, swamp, desert, and trees (i.e. all land cover types except urban, grass, and crops) from the

FAOStat database on land cover. This is intended as a proxy measure for total natural capital per capita that is more inclusive than alternative estimates such as that produced by the World Bank (2006) which are built from a "bottom-up" approach with individual components added over time (Engelbrecht, 2015). The land-cover approach taken here avoids the bias due missing components issues with the World Bank dataset at the expense of greater measurement error.

Table 1. Cross-country dataset

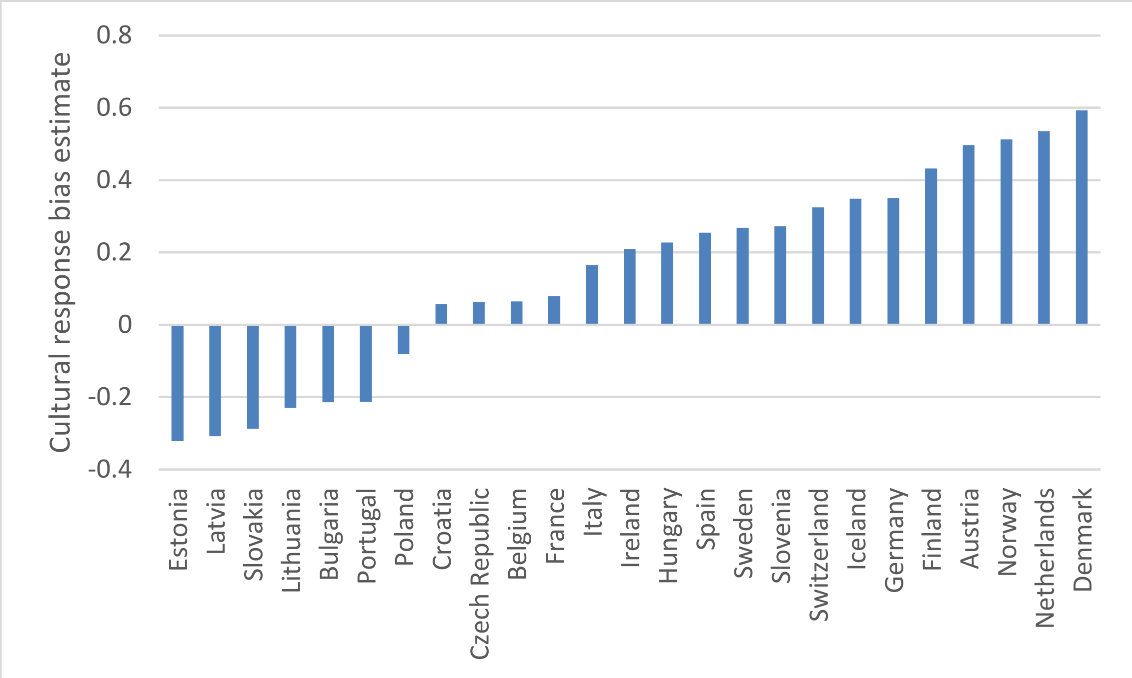
Variable	*Min*	*Max*	*Mean*	*Observations*	*Country coverage*	*Years covered*	*Source*
Real GDP per capita (Y)	*13082.1*	*92226.24*	*35667.67*	*206*	*31*	*2002-2018*	*PWT*
Capital services level per capita (K)	*0.000373*	*0.006282*	*0.002316*	*206*	*31*	*2002-2018*	*PWT*
Human capital per capita (L)	*1165.61*	*3547.506*	*2504.89*	*206*	*31*	*2002-2018*	*PWT*
Tfp at current PPP (ctfp)	*0.549*	*1.5112*	*0.8694*	*206*	*31*	*2002-2018*	*PWT*
Mean life satisfaction (W)	*4.535*	*8.537*	*7.151*	*206*	*31*	*2002-2018*	*ESS*
Mean interpersonal trust	*3.348*	*6.945*	*5.201*	*206*	*31*	*2002-2018*	*ESS*
Corruption perceptions index (S)	*41.00*	*92.00*	*69.30*	*102*	*34*	*2012-2020*	*Transparency international*
Wilderness area per capita (N)	*98.47*	*19208.55*	*1623.56*	*193*	*28*	*2002-2018*	*FAO*
Cultural response bias (θ)	*-0.3214*	*0.5931*	*0.1693*	*31*	*31*	*n/a*	*ESS - derived*

Adjusting for cultural response bias is one of the most significant empirical challenges associated with the proposed analysis. The estimates of cultural response bias in table 1 are derived from an analysis of the ESS based on equation (11). The full results of the model are not reported here[4] as the regression structure is relatively uninteresting and consists largely of two long vectors of dummy variables. Ideally it would be possible to rest these estimates against other comparable estimates of cultural response bias, but there is relatively little available in the literature that could form the basis of a direct comparison.

Exton, Smith, and Vandendreissche (2015) use a similar approach to identifying cultural response bias and find that it accounts for a maximum of approximately 20 percent of cross-country variation in life satisfaction. However, they do not provide country-specific estimates. Senik (2014) uses a slightly more sophisticated version of the same approach and obtains estimates of cultural response bias for a relatively small number of countries. In Senik's analysis the Nordic countries (Norway, Sweden, and Denmark) are characterised by a high positive bias, while Portugal and France have a small negative bias. The only ex Eastern-bloc country reported by Senik has the largest negative coefficient. This pattern is replicated in figure 3 below, which shows the cultural response bias estimates used in this paper.

[4] Full regression results are available on request from the authors.

Figure 3. Cultural response bias



5) Results

Table 2 below reports the results of a wellbeing regression based on equations (3) and (12). This captures the combined effect of the capital stocks on wellbeing from both market and non-market outputs. Columns (A) and (E) correspond to model (3) while columns (D) and (H) correspond to model (12). The intermediate columns (B), (C), (F), and (G) add natural capital and social capital independently to model (3). As a sensitivity test, the same analysis is repeated twice. The first four columns of table 2 (A) to (D) use mean life satisfaction adjusted for cultural response bias as the dependent variable, while the second four columns (E) to (H) use unadjusted mean life satisfaction.

A comparison of the models using adjusted life satisfaction and those using unadjusted life satisfaction shows very little qualitative difference between them with the exception that produced capital (K) has a larger impact on unadjusted life satisfaction under all model specifications than it does on adjusted life satisfaction. Both human capital (H) and produced capital are consistently significant across all model specifications as is social capital (S) for all model specifications that it is included in. Natural capital (N) is significant when included alongside human capital and produced capital but loses significance when social capital is included. An examination of the R^2 shows that the natural capital measure used here adds relatively little to the total variance explained compared to the other three measures.

Table 2. Full capital stocks model

Variable	*Life Sat (adjusted)*	*Life Sat (adjusted)*	*Life Sat (adjusted)*	*Life Sat (adjusted)*	*Life Sat (raw)*	*Life Sat (raw)*	*Life Sat (raw)*	*Life Sat (raw)*
	(A)	*(B)*	*(C)*	*(D)*	*(E)*	*(F)*	*(G)*	*(H)*
ln(L)	1.31***	1.17***	0.99***	0.97***	1.33***	1.20**	0.94**	0.95**
ln(K)	0.79***	0.78***	0.25*	0.25*	1.15***	1.14***	0.48***	0.47***
ln(N)		0.08^		0.01		0.07		-0.01
ln(S)			1.85***	1.82***			2.25***	2.27***
Adj R^2	0.457	0.494	0.692	0.693	0.531	0.556	0.742	0.742

**** p<0.001, ** p<0.01, * p<0.05, ^ p<0.1*

Broadly speaking the results in table 1 can be considered supportive of the capital stocks model if one assumes that the measure of natural capital used here is relatively poor. There is clearly some evidence of an interaction between the social capital measure used here and produced capital, with produced capital having a much lower coefficient once social capital is included in the model. Given that the coefficients here are elasticities, what the interaction suggests is that the impact of the produced capital stock on wellbeing is more sensitive to levels of social capital than is the case for the human capital stock.

Table 3 below examines the relative contributions of the capital stocks to market and non-market output. Columns (J) to (M) estimate equation (6) while columns (N) to (R) estimate equation (10). It is apparent that the picture for market outcomes is similar to that for overall wellbeing (table 2). Human capital, produced capital, and social capital all have positive and significant coefficients. In contrast to table 2, human capital has a smaller impact than produced capital on market outcomes.

Table 3. Market and non-market decomposition

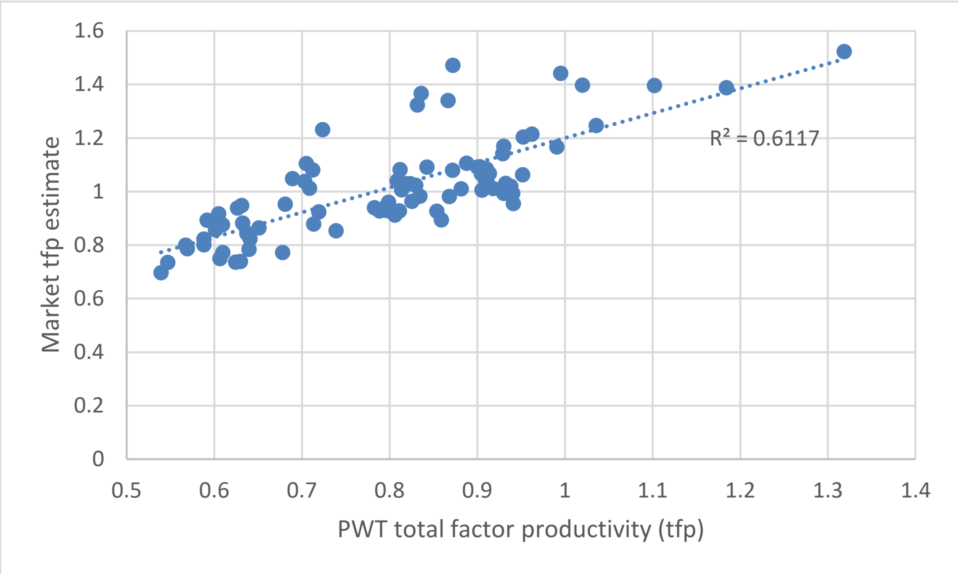
Variable	*Ln(Y)*	*Ln(Y)*	*Ln(Y)*	*Ln(Y)*	$\widehat{W_c} - \theta_c$	$\widehat{W_c} - \theta_c$	$\widehat{W_c} - \theta_c$	$\widehat{W_c} - \theta_c$
	(J)	*(K)*	*(L)*	*(M)*	*(N)*	*(P)*	*(Q)*	*(R)*
ln(L)	0.32*	0.29*	0.24*	0.24*	0.93**	0.84**	0.71**	0.70*
ln(K)	0.66***	0.66***	0.51***	0.51***	0.02	0.01	-0.36**	-0.35**
ln(N)		0.02***		0.00		0.05		0.01
ln(S)			0.51***	0.50***			1.26***	1.24***
Adj R^2	0.773	0.777	0.820	0.820	0.11	0.12	0.30	0.30

**** p<0.001, ** p<0.01, * p<0.05, ^ p<0.1*

The situation for non-market outcomes is quite different. Both human capital and social capital are significant in all versions of the model and the measure of natural capital used is never significant. Produced capital is insignificant in the first two model specifications (N) and (P) but has a significant negative coefficient in the two specifications involving social capital: (Q) and (R). This result is robust to the choice of adjusted or raw life satisfaction data as the dependent variable and to the choice of mean trust or the corruption perceptions index as the measure of social capital. It should be noted that the coefficients in columns (N) to ® cannot be directly compared to the coefficients for market goods in columns (J) to (M) as the non-market coefficients represent $\beta_1\gamma_n$ rather than γ_n. Coefficient ratios can be compared between the market and non-market regressions and it is interesting to note that the ratio of the coefficient for human capital to that for social capital is relatively similar across both sets of regression. However, this is clearly not the case for produced capital.

With the results presented in tables 2 and 3 it is possible to calculate a range of measures of tfp. These include wtfp (tfp with respect to life satisfaction) from columns (A) to (D) of table 2, market tfp from columns (J) to (M) of table 3, and non-market tfp from columns (N) to (R) of table 3. A useful validity test of the models presented in these tables is to compare market tfp from column (J) of table 3 to the estimates of tfp from the PWT (cftp). Figure 4 below shows a scatterplot of market tfp against ctfp from the PWT. Although the correlation is not perfect[5], there is a clear linear relationship between the two measures.

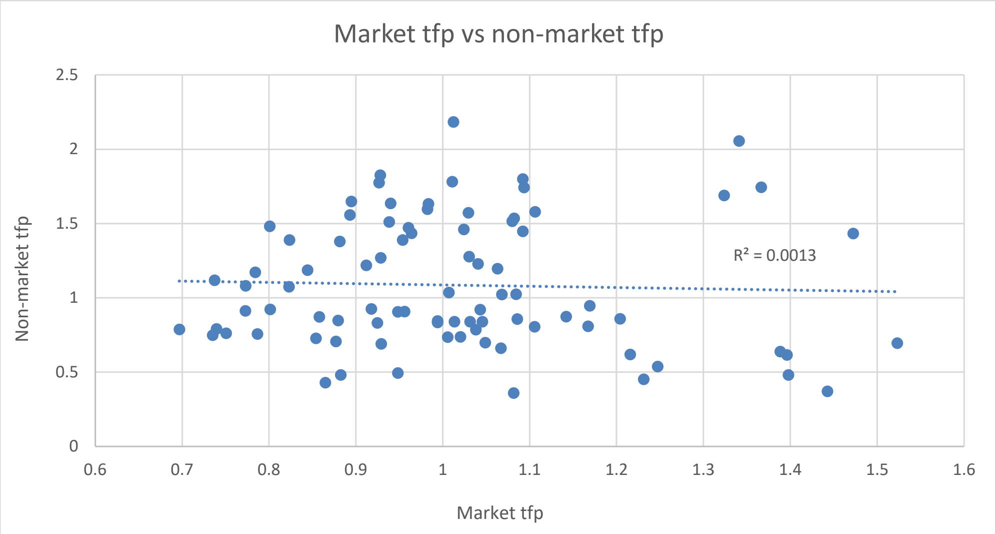
Figure 4. Model estimates of tfp vs PWT estimates



Given that the estimate of market productivity is reasonable, it can be compared with an estimate of non-market productivity calculated in a similar way from column (N) of table 3. This is presented in figure 5 below. It is immediately evident from figure 5 that there is essentially no correlation between market productivity and non-market productivity. This suggests that the production "technologies" of the market and non-market sectors are fundamentally different.

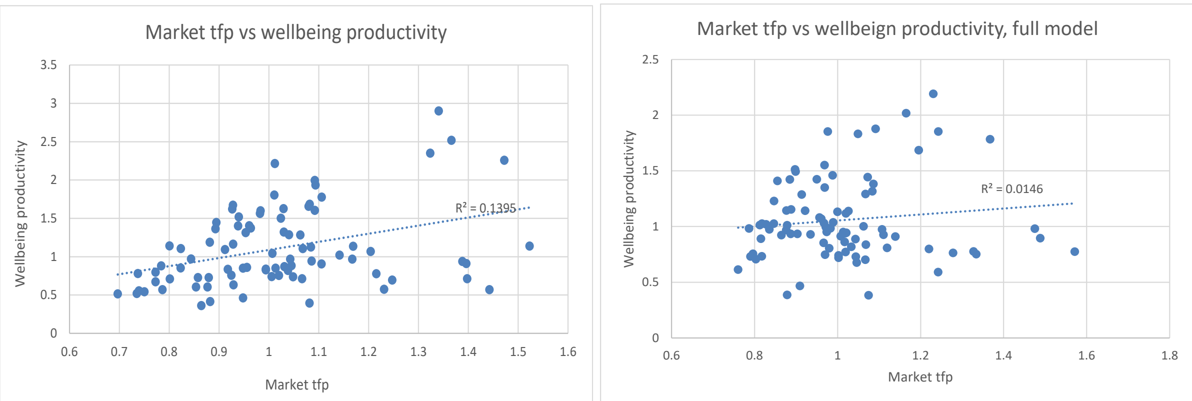
[5] Observations with high productivity in PWT but not in the residual are Ireland, Poland, and one observation for Bulgaria.

Figure 5. Market and non-market productivity



Moving from non-market productivity, figure 6 below compares wtfp to market tfp. Panel I illustrates the relationship where productivity is calculated on the basis of panels (A) of table 2 and (J) of table 3. In this instance the impact of social capital is folded into tfp. Panel II compares productivity estimates based on panels (D) of table 2 and (M) of table 3. This gives a narrower measure of tfp with social capital now accounted for in the capital stocks and therefore not reflected in the productivity measure.

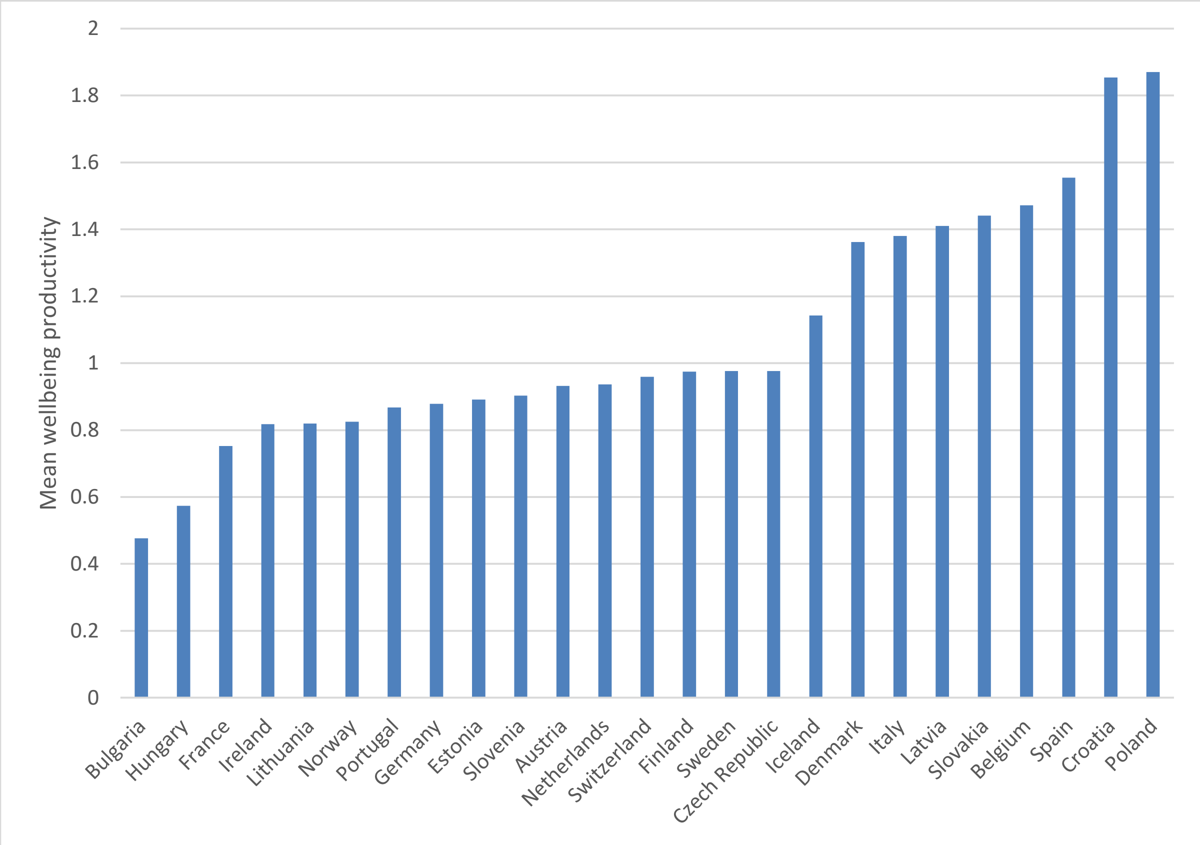
Figure 6. Model estimates of tfp vs PWT estimates



Panel I. *Panel II.*

Since wellbeing is considered a function of both market and non-market output in the capital stocks model, it is unsurprising to see that there is a correlation between market tfp and wtfp. However, this relationship is weak. It is evident in panel I, but only barely exists in panel II. It is evident from both panels in figure 6 that there are significant differences in wtfp across countries. Figure 7 below explores this further, presenting the mean wtfp over the 2002-2020 period for all the countries covered in figure 6. Because figure 7 shows country mean values while figure 6 includes estimates for each country/year observation, figure 7 below contains fewer data points.

Figure 7. Mean wtfp, 2002-2020



One common criticism of tfp as a concept is that measures of it can be hard to interpret. This is doubly the case for the estimates of wtfp provided here both because the dataset used is exploratory and because there is little other literature to provide the basis for comparison. A few observations, however, can be made. First, accounting explicitly for stocks of social capital changes the picture of the Nordic countries in terms of the production of wellbeing. With the exception of Denmark – which records a relatively high wtfp – most of the Nordic countries perform at around the average level despite relatively high life satisfaction. Norway is actually towards the bottom of the table which is consistent with the country's relatively high human, produced, social, and natural capital stocks contrasted against wellbeing levels not very different to the other Nordic countries.

Similarly, while a cross-country analysis of life satisfaction shows a strong post Eastern-bloc effect associated with lower levels of subjective wellbeing (Senik, 2014), looking at wtfp shows a more diverse picture. While some ex Eastern-bloc countries have a very low wtfp (Bulgarian, Hungary), others are amongst the best performing (Poland, Croatia). All four countries are associated with similar low levels of social trust, but Poland and Croatia have far better wellbeing outcomes.

6) Conclusion

This paper investigates the concept of productivity from within the framework of the capital stocks model of wellbeing. In particular, it estimates wtfp – the efficiency with which resources (the capital stocks) are used to produce wellbeing – as a Solow-Swann residual in a modified cross country growth regression. Although the dataset used here is more exploratory than definitive, an interesting picture emerges.

The capital stocks model is supported by the available evidence in that the capital stocks are significant in the production function for wellbeing. Natural capital is an exception here, but this may reflect the relatively poor quality of natural capital data. There is evidence that the market and non-market sectors have very different production technologies, however, and this leads to a relatively low correlation between wtfp and traditional tfp measures.

This article is intended to be exploratory, and it is important therefore to acknowledge that is has significant limitations. Three of these are particularly important. First, the residual approach to estimating tfp faces the inherent issue that the residual of any regression analysis will also incorporate the error term. This is compounded in estimating wtfp in that it is necessary to adjust life satisfaction to account for potential cultural response bias. This means that the estimate if effectively a residual of a residual, with potential error on both sides of the equation.

The issue of adjusting for cultural response bias, however, goes beyond the issues associated with calculating productivity as a residual. As discussed earlier in the paper, cultural response bias is extremely challenging to estimate. Because it cannot be observed directly and is difficult to distinguish from substantive differences in wellbeing caused by unobserved omitted variables, cultural response bias is difficult to control for in a robust fashion. Perhaps the best that can be hoped for here is to test the sensitivity of results to estimates of cultural response bias based on different methodologies.

Even if issues in the estimation of wtfp are ignored, there are still significant challenges in interpreting the results. The decomposition of wtfp into market productivity and non-market productivity illustrates this issue. While market productivity is simply conventional tfp and can be interpreted as such[6], non-market productivity is more complicated to interpret. Because non-market consumption (C_c) is a vector not a quantity, estimated differences in non-market productivity might be due to differences in the relative make-up of C_c across countries rather than differences in the effectiveness with which the capital stocks are used. Different aspects of non-market consumption – such as health status and social contact – might be expected to have different production technologies. With the approach to estimating non-market productivity adopted here it is impossible to distinguish between different non-market consumption bundles and differences in the quality of non-market production technology.

Given the issues identified above, what is the value of attempting to estimate wtfp? First, looking at wtfp is important simply because the concept is implicit in the most widely adopted approaches to measuring wellbeing and assessing sustainability. This can be seen in the academic literature on the capital stocks model (Engelbrecht, 2009; Arrow et al, 2012; Grimes and Qassim, 2018), the approach taken by international organisations (World Bank, 2206; OECD, 2013, 2015; Hamilton and Liu, 2013), and in the analytical frameworks adopted by governments (OECD, 2016; Ormsby, 2018, National Economic and Social Development Office, 2021). Because the capital stocks model is used to inform and evaluate policy decisions it is important to test it. The limitations identified above exist, regardless of whether the model is used in a quasi-anecdotal fashion to justify indicator dashboards or if it is taken more seriously as a quantitative model. However, it is only by exploring the implications of the capital stocks model in a quantitative fashion that some of these limitations are identified.

It is also important to reflect that the challenges associated with estimating wtfp are not unique. Market consumption may have a common metric in terms of market prices, but fundamentally is just as much a vector of different elements as is non-market consumption. This is of particular relevance in the context of the produced capital stock (K). The so-called Cambridge capital controversy, for example, largely revolved around precisely the issue of whether the capital stock could reasonably be treated as a single quantity when it, in fact, consisted of a wide range of different capital items that were not necessarily good substitutes for each other (Cohen and Harcourt, 2003). What is interesting in this comparison is that, while the criticisms of the notion of a single capital stock are clearly valid, this has

[6] Note that the interpretation of conventional tfp is not, itself, uncomplicated. Tfp has no natural units and the aggregate production function approach to estimating tfp has been criticised (e.g. Felipe and McCombie, 2006).

not prevented analyses of economic growth based on an aggregate production function contributing useful insights. Modern endogenous growth theory, for example, builds on and extends this framework (Roemer, 1994).

If the idea of wtfp is worth exploring further, what are the next steps in this research agenda? There would appear to be two obvious directions to explore. First, better data would significantly improve the quality of wtfp estimates compared to the analysis in this paper. The ESS focuses only on a relatively small number of high income countries with relatively high levels of wellbeing and is thus not the ideal dataset from the perspective of examining variation in wellbeing outcomes. This could be addressed either through extending the analysis to include other similar datasets such as the World Values Survey or various national general social surveys (Fleischer, Smith, and Viac, 2016). Alternatively, the Gallup World Poll, although more difficult to obtain, would provide a potentially suitable dataset covering a wider range of countries and with better ability to model cultural response bias (Exton, Smith, and Vandendreissche, 2015).

Better measures of the capital stocks are also important. While social capital might seem relatively abstract, the most widely used proxy measures actually function fairly well (Smith, 2020). Natural capital, on the other hand is extremely difficult to measure. Existing measures tend to be either account for only a small proportion of the total natural capital stock or – as is the case with the proxy measure used in this paper – simply perform poorly.

There is also clearly scope to move beyond the relatively simplistic analytical framework used in this paper. Two obvious extensions would be to explore treating non-market consumption explicitly as a multi-dimensional vector and looking at whether there is evidence of different production "technologies" across the different aspects of non-market production. Introducing non-market consumption also raises the issue as to whether use of the capital stocks is rival across different outputs. Clearly some elements of the capital stocks are strictly rival in that, if they are used to produce one output, they cannot be used to produce another. However, for other elements this is less the case. An educated worker is more productive in the paid market and is also likely to be more effective in producing non-market outputs.

Finally, if wtfp can be measured - even with significant noise – it becomes possible to ask what drives differences between countries. This is a tremendously important policy issue globally, since there is limited scope to increase consumption of some capital stocks globally – particularly natural capital – but low levels of wellbeing in much of the world suggest that there is likely to be significant pressure to raise wellbeing. This tension suggests that identifying the drivers of wtfp adds a potentially important dimension to growth economics.

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