Happiness matters: the role of well-being in productivity

DiMaria, Charles Henri and Peroni, Chiara and Sarracino, Francesco

STATEC

27 June 2014

Happiness matters: the role of well-being in productivity*

Charles Henri DiMaria†, Chiara Peroni‡ and Francesco Sarracino§

June 27, 2014

Abstract

This article is about the link between people's subjective well-being, defined as an evaluation of one's own life, and productivity. Our aim is to test the hypothesis that subjective well-being contributes to productivity using a two step approach: first, we establish whether subjective well-being can be a candidate variable to study Total Factor Productivity; second, we assess how much subjective well-being contributes to productivity at aggregate level through efficiency gains. We adopt Data Envelopment Analysis to compute total factor productivity and efficiency indices using European Social Survey and AMECO data for 20 European countries. Results show that subjective well-being is an input and not an output to production.

Key-words: productivity, subjective well-being, TFP, efficiency gains, life satisfaction, economic growth, DEA.

JEL codes: E23, I31, O47.

*The opinions and views expressed in this paper are those of the authors and do not reflect in any way those of STATEC. The authors would like to thank J.T. Pastor and participants in the VIII North American Productivity Workshop for useful comments. Thanks are also due to Stefano Bartolini.

†Laboratoire d'Economie d'Orléans (LEO); Institut national de la statistique et des études économiques du Grand-Duché du Luxembourg (STATEC).

‡Institut national de la statistique et des études économiques du Grand-Duché du Luxembourg (STATEC).

§Institut national de la statistique et des études économiques du Grand-Duché du Luxembourg (STATEC); Laboratory for Comparative Social Research (LCSR), National Research University Higher School of Economics (Russia); GESIS – Leibniz Institute for the Social Sciences (Germany).

1 Introduction

In recent years, the measurement of human welfare has attracted increased attention from researchers, policy-makers and media. Initiatives aimed at informing on people's welfare in modern societies have multiplied. In 2007 the European Commission hosted a conference titled "Beyond GDP" to identify new tools for a more comprehensive evaluation of people's well-being. Two years later the French Economic Commission, directed by Stiglitz, Sen and Fitoussi, published a report recommending the development of indices of well-being to supplement the more commonly used income-based measures. The "Better Life Initiative", launched by the OECD in 2011, tries to collect internationally comparable measures of well-being.

Among measures of welfare, subjective well-being has become prominent because it is a valuable alternative to monitor people's quality of life beyond traditional economic-based measures such as GDP. Subjective well-being, sometimes also referred to as happiness or life satisfaction, is a self-reported measure of well-being collected through individual-based surveys. Even though the terms life satisfaction, happiness and subjective well-being have different meanings, these terms are often used interchangeably. Section 2 will clarify this distinction. The initial scepticism on the adoption of self-reported measures has been gradually overcome by a large body of research proving that people's evaluation of their own life are relatively easy to collect, widely available and reliable sources of information. An extensive literature, involving various disciplines and scientific domains, supports the reliability of subjective well-being. Subjective well-being correlates with objective measures of well-being such as the heart rate, blood pressure, frequency of Duchenne smiles and neurological tests of brain activity (Blanchflower and Oswald, 2004; van Reekum et al., 2007). Moreover, different proxies of subjective well-being correlate strongly with each other (Schwarz and Strack, 1999; Wanous and Hudy, 2001; Schimmack et al., 2010) and with the judgements about the respondent's well-being provided by friends, relatives or clinical experts (Schneider and Schimmack, 2009; Kahneman and Krueger, 2006; Layard, 2005).

Happiness measures have been adopted in both macro and micro-economic studies to analyze the impact of a wide range of issues such as poverty, inequality, unemployment and inflation on people's welfare (see for instance Di Tella and MacCulloch, 2008; Alesina et al., 2004; Diener et al., 2009; Clark et al., 2012, 2013). Subjective well-being has also been extensively studied in relation with non economic aspects such as aging, gender issues, marital and employment status, childbearing as well as the quality of political institutions (Frey and Stutzer, 2000; Powdthavee, 2007; Stutzer and Frey, 2012). Moreover, some recent studies have also demonstrated that it is possible to promote or protect subjective well-being through public policies (Rogers et al., 2010; Helliwell, 2011a,b; Bartolini, 2013).

Despite the increased interest in well-being, the relation between subjective well-being and economic performance is still an open issue. Productivity is a key measure of economic performance both at macro and micro level. Since the seminal contribution of Solow (1957), the economic literature has largely focused on the determinants of productivity as a way to promote economic growth and wealth. Despite this intensive effort, productivity partly remains a black box. This article investigates whether and to what extent subjective well-being can contribute to explain productivity.

Several empirical studies suggest that happier people are more productive and more satisfied, and proposed various explanations for this relationship (Judge and Watanabe, 1993; Judge et al., 2001; Keyes and Magyar-Moe, 2003; Russell, 2008). Happier workers are more pragmatic, less absent, more cooperative and friendly (Bateman and Organ, 1983; Judge et al., 2001), change their job less often and they are more accurate and willing to help others (Spector, 1997). There is also evidence that happier people are more engaged in their work, earn more money, have better relationships with colleagues and clients, all aspects that enhance work productivity (George and Brief, 1992; Pavot and Diener, 1993a; Spector, 1997; Wright and Cropanzano, 2000). Some studies find that companies with higher average levels of well-being report higher monetary returns than companies in the lowest quartile of employee well-being (Harter and Schmidt, 2000; Harter et al., 2003).

These results have been confirmed also in experimental settings. Oswald et al. (2009) observe that, after controlling for factors such as personal ability, enhancing people's well-being results in a significant and sizeable boost to productivity of about 10 percent. These authors find that much of this gain is explained by an increase in the effort, rather than from a higher precision in executing the task. In a related paper, Proto et al. (2010) observe that productivity is affected by short-run and artificially-induced increases in happiness, as well as by long-lasting shocks such as family bereavement, parental divorce and health problems. Focusing on a group of 179 students from the University of Warwick, the authors confirm that happier people perform better and find that those who experienced significant negative life shocks were less happy, whereas those who experienced significant positive life shocks were happier than those who did not experience any significant change.

In summary, a large body of empirical research, supported by valid theoretical arguments, suggests that happier people are more productive and more committed to their work. This literature, however, is largely based on the analysis of individual level data and ad-hoc experiments which rest almost entirely on small cross-sectional datasets (Harter et al., 2003).

This paper takes a fresh look at the link between well-being and productivity using the tools of efficiency analysis on aggregate country-level data. The focus of our work is the concept of total factor productivity (TFP), a key ingredient of economic growth and a measure of economic efficiency. TFP can be viewed as an overall measure of how well countries use their inputs to production as well as an indicator of technological progress and innovation (Fare et al., 1994b). Usually, TFP is computed by comparing GDP to capital and labour inputs. This study evaluates the TFP performance of countries by computing efficiency "scores", or distances to a best-practise frontier, comparing the use of inputs to outputs. The inputs/outputs set is augmented with subjective well-being . This framework allows us to examine the role of subjective well-being in production processes, and to establish whether it should be regarded as an output or an input to production.

More in detail, we test whether subjective well-being contributes to TFP. The test is carried out using a two-step macroeconomic approach: first, we establish whether subjective well-being can be a candidate variable to study TFP; second, we estimate how much subjective well-being contributes to productive efficiency at aggregate level. This is done adopting data envelopment analysis using key macroeconomic variables and subjective well-being data for 20 European countries. Schematically, the first stage of the analysis assesses whether our measurement of productivity including subjective well-being is reliable. This is done by checking whether the ranking of countries based on standard productivity measurement is confirmed after including well-being. The second stage establishes whether subjective well-being has a significant impact on countries' efficiency.

Our results confirm previous evidence at micro-level and support the idea that people's well-being contributes to TFP rather than being a by-product of production. Hence, promoting people's well-being can be a valuable option to promote economic growth and prosperity.

The paper is structured as follows: section 2 provides an overview of the data used in the this study. Section 3 describes the empirical strategy and provides details about the method. Section 4 present findings, and section 5 provides some final remarks.

2 Data

The paper uses annual observations on GDP, labour and capital stock sourced from AMECO, the macroeconomic database maintained by the European Commission. The measure of subjective well-being comes from the European Social Survey (ESS) and covers four time periods, 2004, 2006, 2008 and 2010[1]. The ESS database includes observations on individuals which were interviewed over 4 time periods along with survey weights.[2] Table 1 presents average values of the main variables in this analysis.

Individuals' well-being is measured using answers to the following question: "*All things considered, how satisfied are you with your life as a whole nowadays? Please answer using this card, where 0 means extremely dissatisfied and 10 means extremely satisfied*"; answers are coded using a 1 to 10 scale.[3] In principle, also another proxy of well-being is available in the ESS, i.e. people's happiness as monitored through answers to the question: "Taking all things together, how happy would you say you are?" whose answers are also coded using a 1 to 10 scale. Despite being used as synonyms of well-being, happiness and life satisfaction are different concepts. Happiness is generally regarded as an emotional measure of well-being, whereas life satisfaction is considered a cognitive evaluation of well-being and it is therefore regarded as more reliable (Diener, 2006)). Here we adopt life satisfaction as proxy of subjective well-being.

Country data on subjective well-being are weighted averages of individuals' well-being. Missing values on individuals have been replaced using a simple imputation scheme that employs the mode of the observations on individuals in the same strata. In other words, for a given country, missing values are filled by taking the sample mode of the individuals having the same weight.[4] This choice allows to retain all observations and to use the sample weights provided in the

[1] The year 2002 is not included as some of the countries in our sample were not surveyed.

[2] ESS survey documentation is available at http://ess.nsd.uib.no/ess/.

[3] Various studies document that the 1 to 10 scale is a standard and reliable scale for measuring well-being (see Pavot and Diener, 1993b; Krueger and Schkade, 2008).

[4] Missing data for Greece and the Czech Republic in 2004 were replaced by the average of values recorded for 2002 and 2006.

Table 1: **Descriptive Statistics.**

Country	Codes	GDP (EUR/PPP)	Labour	Capital	Well-being
Belgium	BE	313.93	6802.75	809.70	7.40
Switzerland	CH	348.23	7243.75	995.34	8.02
Czech Republic	CZ	123.60	9083.82	345.10	6.44
Germany	DE	2325.83	56585.50	6904.09	6.84
Denmark	DK	210.05	4383.03	476.76	8.45
Estonia	EE	11.63	1189.31	30.59	6.24
Spain	ES	940.05	32810.57	3336.86	7.29
Finland	FI	163.77	4171.95	410.43	7.97
France	FR	1754.61	39633.90	5369.06	6.29
United Kingdom	GB	1644.47	47830.28	4589.72	7.07
Greece	GR	199.16	9544.37	719.72	6.05
Hungary	HU	85.53	8205.18	180.53	5.53
Ireland	IE	167.41	3670.54	471.99	7.19
Netherlands	NL	536.34	11812.95	1452.38	7.57
Norway	NO	236.76	3538.00	641.63	7.81
Poland	PL	274.68	31010.17	524.37	6.69
Portugal	PT	157.08	9807.30	440.80	5.65
Sweden	SE	306.18	7192.63	919.29	7.86
Slovenia	SI	30.75	1621.47	69.46	6.94
Slovakia	SK	56.01	3829.14	86.18	6.11

Legend: Average values of variables. Units: GDP and capital stock are in billion euros and converted using purchasing power parities (PPP), employment is measures in thousand workers (FTE).
Data source: AMECO, ESS.

original database.[5] After imputation, we computed country average well-being scores for each year in the survey.[6]

Table 2 lists the 20 European countries in our sample along with the average scores of subjective well-being for each period, the average growth rate between periods, and the overall average score. We observe that subjective well-being varies widely across countries and over time. The most satisfied countries are Denmark and Switzerland. Nordic countries such as Finland, Norway and Sweden have averages close to 8. In contrast, Portugal and Hungary are the least satisfied countries with averages below 6. The majority of countries exhibits an increase in well-being over the period, whereas the trend is flat in France, Denmark and Finland. Greece and Ireland, on the contrary, experienced the largest fall in well-being over the period considered. Overall, data suggest that well-being changes have been more sustained in new European member states than in older ones, thus suggesting the possibility of convergence.

[5] Removing an observation would require to compute new sample weights, but information on strata is not available, while keeping the sample fixed has no effect on the weights.

[6] Note that average well-being is a bounded variable measured on a continuous scale from 0 to 10. Thus, we do not need to adopt DEA frameworks designed to deal with integer values.

Table 2: **Average subjective well-being by country.**

Country	**2004**	**2006**	**2008**	**2010**	**average**	**% growth**
BE	7.43	7.41	7.27	7.51	7.40	0.36
CH	8.01	8.03	7.91	8.14	8.02	0.56
CZ	6.41	6.49	6.57	6.30	6.44	-0.53
DE	6.70	6.71	6.84	7.11	6.84	2.03
DK	8.47	8.48	8.52	8.35	8.45	-0.46
EE	5.89	6.37	6.20	6.52	6.24	3.56
ES	7.12	7.45	7.26	7.32	7.29	0.93
FI	8.00	7.99	7.94	7.94	7.97	-0.24
FR	6.37	6.32	6.26	6.21	6.29	-0.87
GB	7.03	7.13	7.02	7.10	7.07	0.31
GR	6.39	6.19	5.98	5.65	6.05	-4.01
HU	5.65	5.33	5.31	5.84	5.53	1.32
IE	7.69	7.48	7.14	6.46	7.19	-5.64
NL	7.48	7.48	7.62	7.69	7.57	0.93
NO	7.66	7.76	7.89	7.93	7.81	1.18
PL	6.22	6.67	6.87	7.01	6.69	4.04
PT	5.62	5.47	5.62	5.87	5.65	1.53
SE	7.84	7.83	7.86	7.91	7.86	0.28
SI	6.90	6.97	6.93	6.97	6.94	0.36
SK	5.59	6.08	6.37	6.41	6.11	4.73

Legend: % growth is the average of rates of growth recorded over two periods.
Data source: European Social Survey, 2004 - 2010.

3 Methodology

This article investigates the relation between well-being and productivity using the tools of *efficiency analysis*. Below we describe our strategy in detail.

The economic literature offers many definitions of productivity, a key concept to assess macro and micro-economic performances. Here, we adopt the concept of productive efficiency, that is, we measure productivity by comparing outputs of production to the inputs used in producing them.[7] This approach is based on the idea that, given certain levels of inputs use and the available technology, there exists a level of output that cannot be exceeded — and might not be attained — by the operating economic units (firms, industries, or countries). These "optimal" levels of output describe the so-called *efficient (or best-practise) frontier*. The gap (*distance*) between the maximum attainable output and the level of production recorded for each operating unit is interpreted as a measure of the operational inefficiency of that unit. Thus, in this framework, production possibility sets – i.e. pairs of outputs and inputs – substitute the idea of production function used in mainstream economic studies as a basis to compute productivity.[8]

In practical applications, a computational method called Data Envelopment Analysis (DEA) is used to compare outputs to inputs of production; this method simultaneously estimates the efficient frontier and efficiency scores based on the distances of the operating units from the frontier. This is done using observed data on output and inputs, under minimal assumptions on the form of the frontier. Studies that have applied this method at country level have usually compared aggregate output to capital and labour (Fare et al., 1994b,a). In this context, the computed distances are interpreted as measures of Total Factor Productivity (TFP), which allow to rank countries according to their ability to use their inputs efficiently. A further advantage of DEA is that it allows to consider multiple outputs at the same time allowing researchers to analyse numerous policy issues. For example, it is possible to compute adjusted measures of TFP that account for environmental degradation as an undesirable output of the production process (Zhou et al., 2010; Fare et al., 1989).

Our goal is to determine whether well-being is an output and, if not so, an input to production, and to estimate how much it contributes to productivity.[9] To do so, we first assess whether subjective well-being is an input or output of the production process and whether it provides valid TFP indeces. As this is the case, we then proceed to quantify the efficiency gains generated by the inclusion of subjective well-being in the set of inputs to production.

[7]This approach was first formalised by Farrell (1957), who explicitly distinguished the idea of productive efficiency from allocative efficiency in production.

[8]For more details on the method, one can see Fare et al. (1994a). These authors present the theoretical foundation of the approach, while Coelli et al. (2005) provide an accessible introduction to efficiency measurement.

[9]Subjective well-being is a legitimate input to production, as it can be regarded as a "discretionary" input in the sense of Banker and Morey (1986). Discretionary inputs are those inputs that can be controlled by managers.

3.1 Reliability of TFP indices accounting for subjective well-being

We compute DEA efficiency scores using observations on GDP, labour and capital for each country and period. GDP serves as a measure of output, while capital and labour are inputs to production.[10] Then Malmquist indices of TFP are given by the average of the efficiency scores over two adjacent periods. These indices permit to rank countries according to their productivity performance. We also compute adjusted Malmquist indices of TFP accounting for subjective well-being as an output or as an input of the production process. We use a statistical test to check that the rankings obtained with subjective well-being are not significantly different from the standard Malmquist index-based ranking. If this is the case, we conclude that it is sound to consider subjective well-being as an output or input to production.

More formally, let y and x denote, respectively, outputs and inputs to production, M the number of outputs, N the number of inputs and K the number of countries. Computing measures of country's efficiency requires solving, for each country k and each period t, linear programs (LP) formulated as follows:

$$[D^t(x_j^t, y_j^t)]^{-1} = Max\ \theta_j^t \tag{1}$$

$$s.t.\ \sum_{k=1}^{K} \mu_k^t y_{mk}^t \geq y_{mj}^t \theta_j^t \qquad m = 1, \ldots, M \tag{2}$$

$$\sum_{k=1}^{K} \mu_k^t x_{nk}^t \leq x_{nj}^t \qquad n = 1, \ldots, N \tag{3}$$

$$\mu_k^t \geq 0 \qquad k = 1, \ldots, K \tag{4}$$

Note that, for the time being, $M = 1$, that is, GDP is the sole output, and $N = 2$ (inputs are capital stock and labour). The value taken by the distance function $D^t(x_j^t, y_j^t)$ tells to what extent a country could increase its GDP by using available resources more efficiently (given the available technology). D takes values between zero and one. If a country is efficient, then $D = 1$ and that country cannot attain higher levels of GDP without increasing the use of inputs to production. In contrast, countries with values of D below unity could produce more (achieve higher levels of GDP) using more efficiently the existing resources.[11]

Using this framework it is possible to construct measures of how efficiency changes over time. Under constant returns to scale, such measures are interpreted as indices of TFP. Developing an idea first suggested by Malmquist (1953), Caves et al. (1982) defines the Malmquist productivity index as follows:

$$M^{t+1} = \frac{D^t(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)}; \tag{5}$$

[10] It is often argued that capital stock should be disaggregated to distinguish the intangible stock from physical capital, and human capital should be included in the analysis as well. Not doing so would lead to an under-estimate of capital stock and biased TFP estimates. However, capital stock estimates are difficult in themselves, even more so to obtain reliable estimates of intangibles and human capital, due to issues of data availability and comparability. Thus, we prefer to employ a standard aggregate measure of capital stock. We also mantain that this choice does not alter the results of this analysis, with respect to whether well-being is an output or input to production.

[11] We assume that the production process is characterized by constant returns to scale.

For each operating unit k, this index is the ratio of the distances to the efficient frontier at time t computed comparing output and inputs of the periods t and $t+1$. Thus, the Malmquist index tells how the efficiency of operating units evolves between two periods. Doing so requires "fixing" the technology (expressed by the frontier) at a certain point in time. Clearly, it is also possible to write the same index using the technology in $t+1$. To avoid the arbitrary choice of a reference technology, Fare et al. (1994a) propose to use a geometric average of the Malmquist indices obtained using the technologies available in t and $t+1$:

$$M^{t,t+1} = \left[\left(\frac{D^t(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \right) \left(\frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^{t+1}(x^t, y^t)} \right) \right]^{\frac{1}{2}}; \tag{6}$$

Equation 6 considers how much a unit could produce using the inputs available in $t+1$, if it used the technology at time t, and how much a unit could produce using the inputs available in t, if it used the technology available in $t+1$, and takes the geometric mean of the answers to these two questions. If, for example, the output resulting from the use of inputs in $t+1$ were halved when using as reference technology the frontier in t, and the output from the use of inputs in t were doubled when using as reference technology the frontier in $t+1$, the index above would show that a substantial technology progress has occurred from period t to $t+1$.

We proceed by computing measures of efficiency that include subjective well-being first in the output than in the inputs set. This provides "adjusted" (to well-being) Malmquist indices of productivity.

As highlighted above, Malmquist indices allow us to rank countries according to their productivity performance. (For a given country, an aggregate overall measure of performance is given by the average of TFP changes over the period analysed.) The country rankings suggested by the three Malmquist indices computed in the first stage of the analysis should not be significantly different from each other, regardless of the role of well-being in production. Indeed, a significantly different ranking would suggest that either it is not possible to rank countries by TFP changes (as measured by the level of GDP compared to Capital and Labour inputs), which is hardly plausible, or that the adjusted indices are measuring something else than countries' productivity performances.[12]

To compare the country ranking given by the Malmquist productivity index to those from the adjusted indices, we use the Spearman rank test for ordinal data. Countries are ranked from 1 to K according to increasing values of productivity performance. Let $d_k = m_k - m_k^a$ be the difference between the position of each observation on two different rankings. (In other words, d denotes the discrepancy between the rank of country k given by the Malmquist index of TFP m and the rank of the same country according to the well-being-adjusted Malmquist index m_k^a.) The following test statistics is computed:

$$r_s = 1 - \frac{6 \sum_{k=1}^{K} d_k^2}{K(K^2 - 1)} \tag{7}$$

[12]DEA compares an aggregate measure (weighted-sum) of variables in the so-called output sets to an aggregate measure of variables in the input set. (The LP problems compute optimal weights so that the ratio of such aggregates lies between 0 and 1.) Thus, one could add *nuisance* variables, that is variables that are not linked with the production process, and still obtain an index. Nonetheless, if the nuisance variables are neither inputs nor outputs in the sense of production economics, the new index is likely to behave differently from TFP indices, computed using the same methodology.

The observed values of the test statistic are then compared to adequate critical values of the Spearman's rank correlation coefficient. This checks whether the rankings obtained comparing standard Malmquist indices and those obtained with the "adjusted" Malmquist indices are significantly different.

3.2 Assessing the impact of subjective well-being

After checking whether subjective well-being is a candidate variable to model productivity, the second stage of our empirical strategy establishes whether subjective well-being is an output or an input to production.

To this purpose, we implement a test developed by Pastor et al. (2002), which proves to perform well under most situations (Nataraja and Johnson, 2011). The test works as follows. Firstly, efficiency indices are computed using the linear program of equation 1. This is done twice, one time with subjective well-being included as an input, another time with subjective well-being included as an output. Then, the distances (efficiency scores) obtained are used to compute the optimal values of GDP that would be attained if countries were using the inputs efficiently. (In other words, if we compared the original set of inputs to the rescaled values of GDP, we would get a value of one for all countries' efficiency scores.) Finally, efficiency indices are computed again using the optimal values of GDP, but omitting subjective well-being in the set of inputs (or outputs). Any resulting loss in the values of efficiency scores measures the effect of subjective well-being. Following Pastor et al. (2002), a change in efficiency of more than 10 percent obtained for at least 15 percent of countries would signal a significant role of well-being as an input (or output) to production. These authors show that, if a country is assigned a value of 1 when efficiency changes by more than 10 percent and 0 otherwise, the sum of such 1s over the countries in the sample follows a Binomial distribution. Therefore, a simple binomial test can be performed:

$$T = \sum_{j=1}^{N} T_j \sim \quad \textit{Binomial} \quad (N-1, p_0 = 0.15) \tag{8}$$

where

$$\begin{aligned} T_j \quad = \quad & 1 \;\; \text{if change in efficiency} > 0.1 \\ & 0 \quad \text{otherwise,} \qquad\qquad\qquad j = 1, \ldots, N \end{aligned}$$

In summary, the first stage of our strategy assesses whether subjective well-being can be considered as a valid variable to explain production processes. The second stage establishes whether and to what extent subjective well-being significantly contributes to total factor productivity.

4 Results

This section presents three measures of TFP according to the different hypothesis on the role of subjective well-being in production. Then, it compares the country rankings compiled on the basis of these measures using a formal statistical criterion, the Spearman rank test.

A first set of results is presented in table 3. The listed variables are measures of TFP and country rankings based on productivity performances. The rankings are based on three different measures of TFP: the first one excludes subjective well-being ($TFP-W$); the second and the third measures include subjective well-being as an input (TFP_I) and as an output(TFP_O) of production, respectively. The last row in the table reports values of Spearman correlations between pairs of rankings. Switzerland and Czech Republic have the highest productivity growth, followed by Slovakia; a numerous group of countries has a stable productivity outlook, while in half of the sample productivity decreases. In Great Britain and Hungary the decrease is dramatic.

The results support the reliability of the TFP index: the inclusion of subjective well-being in the model does not alter the country rankings, but it impacts the efficiency measures. The Spearman rank correlation test does not support the existence of significant differences among the rankings of the countries. This confirms that all proposed measures of TFP are valid, and it suggests that subjective well-being can be regarded as a candidate variable for being an input or an output to production.

To test whether the contribution of subjective well-being to TFP is significant, we proceed by computing efficiency gains that occur when TFP is computed accounting for subjective well-being.

Firstly, efficiency scores, i.e. the distances of each country from the efficient frontier, are computed including subjective well-being in the set of inputs (outputs), which gives the following efficiency scores:

$$D_i^I(K, L, SWB; GDP)$$
$$D_i^O(K, L; SWB, GDP)$$

(Here, the super-scripts I and O mean, respectively, that subjective well-being is included as an input or as an output, while i denotes the country.) Country i's GDP is then multiplied by the distance to the frontier to obtain the optimal output value for that country (denoted by GDP_i^r), as follows:

$$GDP_i^{r,I} = GDP_i * D_i^I(K, L, SWB; GDP) \tag{9}$$
$$GDP_i^{r,O} = GDP_i * D_i^O(K, L, SWB; GDP) \tag{10}$$

Finally, the optimal GDP is used to compute the same distances when subjective well-being is omitted from the output (input) set. The latter are denoted by $D_i^I(K, L; GDP^{r,I})$ and $D_i^O(K, L; GDP^{r,O})$, respectively. The comparison of the distances computed with and without subjective well-being provides a measure of the efficiency gains generated by subjective wellbeing and, therefore, of the contribution of subjective well-being to TFP. This is done by taking the ratio of the the two distances, as follows:

$$R_i = \frac{D_i^I(K, L, SWB; GDP^{r,I})}{D_i^I(K, L; GDP^{r,I})} \tag{11}$$

The idea suggested by Pastor et al. (2002) is that, in such way, changes in efficiency can only be attributed to the omitted variable (subjective well-being in this case). Note that rescaling GDP amounts to impose that all countries are efficient when subjective well-being belong to the output (input) set. Thus,

Table 3: **Average TFP growth and country rankings.**

Country	TFP_W	TFP_I	TFP_O	$rankW.$	$rankI.$	$rankO.$
BE	-0.40	-0.30	-0.40	8	10	9
CH	9.70	9.80	9.60	1	1	1
CZ	9.50	9.40	9.50	2	2	2
DE	1.00	0.80	1.00	4	5	4
DK	-1.20	-1.10	-1.10	13	12	13
EE	-4.50	-4.50	-2.00	18	18	15
ES	-3.10	-3.10	-3.10	16	17	17
FI	-0.70	-0.70	-0.40	10	11	10
FR	-1.10	0.80	-1.10	12	8	12
GB	-8.30	-7.80	-8.30	20	20	20
GR	-3.20	-2.90	-3.20	17	16	18
HU	-7.80	-7.20	-7.80	19	19	19
IE	-1.60	-1.30	-2.70	14	13	16
NL	0.40	0.80	0.40	6	7	6
NO	-0.50	0.10	0.10	9	9	8
PL	0.30	1.40	0.30	7	4	7
PT	-0.80	-1.50	-0.80	11	14	11
SE	0.70	0.80	0.60	5	6	5
SI	-2.50	-2.50	-1.30	15	15	14
SK	4.00	4.10	3.50	3	3	3
Spearman					0.96	0.98

Legend: the first three columns give average TFP growth (in percent) under different hypothesis on the roles of subjective well-being in the production process. Average growth rates have been computed as geometric means over the period. Thus, TFP denotes productivity indices computed without subjective well-being; TFP_I and TFP_O denote TFP measures computed including subjective well-being respectively as input (I) and output (O) to production. The second last three columns report the positions of the countries in a ranking formulated according to their productivity performances. Spearman is the Spearman's rank correlation.
Source: authors' computations on ESS and AMECO data.

Table 4: **Efficiency gains generated by subjective well-being.**

	Input					Output				
	2004 ratio	2006 ratio	2008 ratio	2010 ratio	average	2004 ratio	2006 ratio	2008 ratio	2010 ratio	average
BE	1.06	1.04	1.04	1.00	*1.04*	1.00	1.00	1.00	1.00	1.00
CH	1.08	1.06	1.04	1.00	*1.05*	1.00	1.00	1.00	1.00	1.00
CZ	1.10	1.10	1.18	1.14	**1.13**	1.00	1.00	1.00	1.00	1.00
DE	1.32	1.29	1.17	1.26	**1.26**	1.00	1.00	1.00	1.00	1.00
DK	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.00
EE	1.00	1.00	1.00	1.00	1.00	1.39	1.49	1.72	1.80	**1.60**
ES	1.11	1.08	1.25	1.23	**1.16**	1.00	1.00	1.00	1.00	1.00
FI	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.01	1.02	1.01
FR	1.27	1.26	1.15	1.32	**1.25**	1.00	1.00	1.00	1.00	1.00
GB	1.11	1.07	1.27	1.27	**1.18**	1.00	1.00	1.00	1.00	1.00
GR	1.08	1.06	1.16	1.09	**1.10**	1.00	1.00	1.00	1.00	1.00
HU	1.13	1.14	1.26	1.20	**1.18**	1.00	1.00	1.00	1.00	1.00
IE	1.00	1.00	1.01	1.00	1.00	1.03	1.02	1.01	1.03	1.02
NL	1.13	1.10	1.07	1.10	**1.10**	1.00	1.00	1.00	1.00	1.00
NO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
PL	1.18	1.15	1.32	1.29	**1.24**	1.00	1.00	1.00	1.00	1.00
PT	1.11	1.10	1.20	1.12	**1.13**	1.00	1.00	1.00	1.00	1.00
SE	1.06	1.04	1.04	1.00	*1.04*	1.00	1.00	1.00	1.00	1.00
SI	1.00	1.00	1.00	1.00	1.00	1.12	1.15	1.18	1.26	**1.18**
SK	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Legend: the first four columns provide the R_i ratios from equation 11 for each period of the sample and each country when subjective well-being is an input to production; the fifth column reports period averages for each country. The remaining columns give the same information when subjective well-being is an output to production.
Source: authors' calculations on ESS and AMECO data.

the top term in the ratio R_i is, by construction, always equal to one, while the bottom term can take any values between zero and one. Any significant deviation of the efficiency scores from 1 indicates that subjective well-being matters to efficiency. In particular, significantly large efficiency gains generated by well-being imply values of R_i well above 1. Table 4 presents the ratio of efficiency scores computed using the procedure outlined above.

When subjective well-being is considered as an output, the estimated efficiency scores do not change significantly. One can see that the ratio of the efficiency scores computed with well-being to the scores computed without well-being is for nearly all countries and all periods about 1, with the exception of Estonia (EE) and Slovenia (SI). These results tell us that well-being should not be considered an output to production (or, in other words, regarded as a positive externality of a production process).

Hence, we repeat the same computations considering well-being a (discretionary) input to production. Results shows that, in this case, 13 out of 20 countries exhibit a value of the ratio R_i greater than 1; in 10 countries the improvement in performance amounts to more than 10 percent (reported in bold in the table).[13] The binomial test of equation 8 confirms, at the one percent significance level, that well-being should be regarded as an input to production. (Recall that the test requires an improvement in efficiency by at least 10 percent in at least 15 percent of countries for the null hypothesis not to be rejected.) When considering a proportion of 30 percent of countries, the same conclusion can be reached at a 5 percent confidence level. These results are consistent across countries and over time.[14]

Figure 1 provides a graphical summary of the results presented above. The figure ranks countries according to the average percent efficiency gain per unit of subjective well-being. The countries where subjective well-being contributes the most to efficiency gains are Germany, France and Poland. We also document that, in 7 out of 20 countries, subjective well-being does not play any significant role on productivity. In this group, we find countries such as Slovakia, Slovenia, Estonia, but also Denmark, Finland, Norway and Ireland. Estonia and Slovenia are two important exceptions because, as documented in the last column of table 4, in these cases subjective well-being is an output of productivity, rather than an input.

These results are mirrored by the TFP indeces reported in column 3 of tab. 5 in the Appendix. In this case it is possible to compare the scores of the TFP computed with and without the input of subjective well-being. As pointed out above, the inclusion of subjective well-being in the computation leads to slightly larger scores than in absence of well-being. This further confirms the observation that subjective well-being is part of the ingredients of TFP and that its role is not homogeneous across countries.

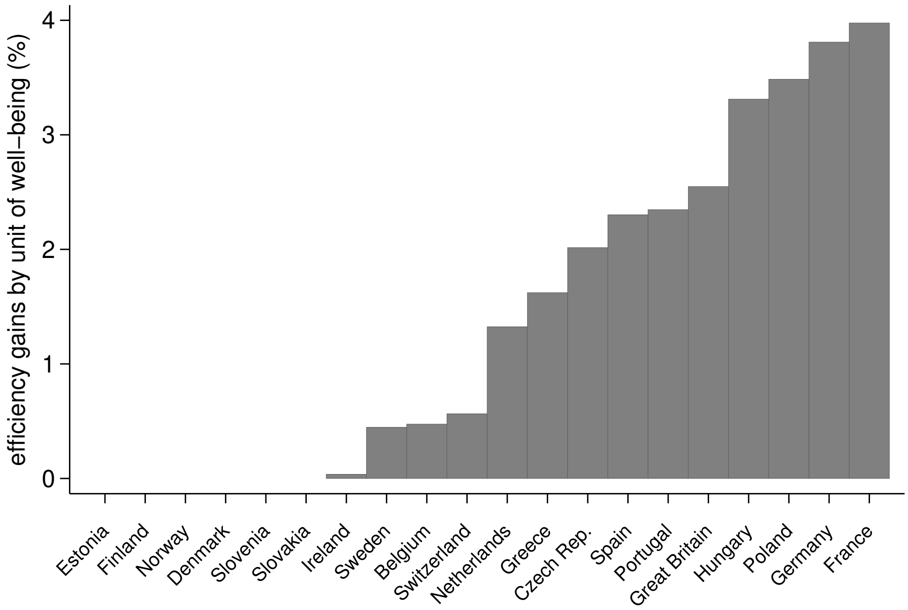
5 Conclusions

This article focuses on the relationship between subjective well-being — people's declarations of their satisfaction with their own life — productive efficiency and TFP. Several micro-econometric, psychological and experimental studies provided theoretical and empirical support to the hypothesis that subjective well-being fosters productivity. These studies, however, are largely based on the analysis of individual-level data, and ad-hoc experiments which rest almost entirely on small cross-sectional data-sets. Present work contributes to this literature adopting a new empirical strategy to overcome such limitations. It does so by testing whether well-being explains total factor productivity (TFP) changes using Data Envelopment Analysis on aggregate data. The test is robust to reverse causality. Results rest on a sample of 20 European countries observed between 2004 and 2010. Data on subjective well-being are drawn from the European Social Survey, whereas measures of labor, capital and GDP are

[13] A score of 1.26, for example, as in the case of Germany, means that a country could increase its output by 26% by including well-being in the input set. Viceversa, excluding well-being from the input set would result in a decrease of the country's output by 26%. Care is needed, however, in interpreting this result as computations do not refer to the observed frontier but to the rescaled frontier.

[14] Following Simar and Wilson (1998, 2000b,a), efficiency estimates were also obtained using a bootstrap procedure, rescaling GDP so that bootstrap estimates were close to unity. This confirmed the main result in the article that subjective well-being should not be regarded as an output to production: also in this case, ten countries exhibit a large marginal effect when well-being is included as an input to production. Results available form authors on request.

Figure 1: Efficiency gains from subjective well-being.*



**Source: authors' computation on ESS and AMECO data.*

sourced from the AMECO database.

After checking whether subjective well-being contributes to TFP, we estimate to what extent well-being matters. Our first conclusion is that subjective well-being is an ingredient of productivity, which confirms the results of previous literature. In particular, we identified a change in productive efficiency of more than 10 percent in 10 out of 20 countries, thus signaling a significant role of subjective well-being as an input to production. Viceversa, available data do not support any claim concerning the role of productivity in enhancing subjective well-being. Indeed, only in 2 countries well-being results as the output of TFP and, according to Pastor et al. (2002), this result is not significant. Our second conclusion is that on average subjective well-being explains about 9 percent of the efficiency gains in the overall sample, that in seven cases these gains are zero and that in three cases well-being explains about 25 percent of the gains. Obviously, these results are mirrored by TFP indexes which show significant heterogeneity across countries.

In summary, the empirical analysis in this study documents that, along with the other economic dimensions, subjective well-being plays a role for productivity. This evidence adds to the previous theoretical and empirical debate on the role of well-being for productivity suggesting an "optimistic" path for development policies: it is possible to promote productivity through well-being. Contrary to the common belief that people need incentives to give up their well-being for their jobs, available evidence suggests that caring for people's well-being might positively affect TFP and, more in general, economic growth.

This observation opens the way to new policies aimed at fostering economic growth through the promotion of people's satisfaction with their lives. Many studies have shown that it is possible to take concrete actions to support and promote people's well-being beyond the traditional sphere of economic policies(see, for instance, Helliwell, 2011a; Bartolini, 2013). In particular, it seems that enhancing individuals' freedom and autonomy, self-expression, social participation, feeling of belonging, and control over their own time and space would significantly contribute to people's well-being.

More in general, this study emphasizes that promoting people's well-being would not only be desirable *per-se*, but it would also be a valuable option to promote productivity and, therefore, economic growth and prosperity. The study also suggests venues for further research. An interesting issue, and one relevant to policy-making, is the quantification of the exact gain in productivity that is possible to obtain in correspondence of an increase in well-being. Another issue is disentangling which part of the contribution to TFP is due to changes in effort and to technological changes. Happier people might contribute to TFP because they work harder or because they are more creative and contribute more to innovation. Future research will shed some light on this issues.

A Appendix: TFP growth

Table 5: **Average TFP growth and country rankings.**

Country	TFP_W	TFP_I	TFP_O	$rank_W$	$rank_I$	$rank_O$
BE	0.996	0.997	0.996	8	10	9
CH	1.097	1.098	1.096	1	1	1
CZ	1.095	1.094	1.095	2	2	2
DE	1.01	1.008	1.01	4	5	4
DK	0.988	0.989	0.989	13	12	13
EE	0.955	0.955	0.98	18	18	15
ES	0.969	0.969	0.969	16	17	17
FI	0.993	0.993	0.996	10	11	10
FR	0.989	1.008	0.989	12	8	12
GB	0.917	0.922	0.917	20	20	20
GR	0.968	0.971	0.968	17	16	18
HU	0.922	0.928	0.922	19	19	19
IE	0.984	0.987	0.973	14	13	16
NL	1.004	1.008	1.004	6	7	6
NO	0.995	1.001	1.001	9	9	8
PL	1.003	1.014	1.003	7	4	7
PT	0.992	0.985	0.992	11	14	11
SE	1.007	1.008	1.006	5	6	5
SI	0.975	0.975	0.987	15	15	14
SK	1.04	1.041	1.035	3	3	3
Spearman					0.96	0.98

Legend: the first three columns gives average values of the Malmquist productivity indices computed under different hypothesis on the roles of subjective well-being in the production process. TFP_W *denotes productivity indices computed without subjective well-being;* TFP_I *and* TFP_O *denote TFP measures computed including subjective well-being respectively as input (I) and output (O) to production. The second last three columns report the positions of the countries in a ranking formulated according to their productivity performances. Spearman is the Spearman's rank correlation.*
Source: authors' computations on ESS and AMECO data.

References

Alesina, A., Di Tella, R., and MacCulloch, R. (2004). Inequality and happiness: are Europeans and Americans different? *Journal of Public Economics*, 88(9):2009–2042.

Banker, R. and Morey, R. (1986). Efficiency analysis for exogenously fixed inputs and outputs. *Operation research*, 34:513–521.

Bartolini, S. (2013). *Manifesto for Happiness: Shifting society from money to well-being*. Pennsylvania University Press. forthcoming.

Bateman, T. and Organ, D. (1983). Job satisfaction and the good soldier: the relation between affect and employee "citizenship". *Academy of Management Journal*, 261:587 – 595.

Blanchflower, D. and Oswald, A. (2004). Money, sex and happiness: An empirical study. *The Scandinavian Journal of Economics*, 106(3):393–415.

Caves, D., Christensen, L., and Diewert, W. (1982). The economic theory of index numbers and the measurement of input, output, and productivity. *Econometrica*, 50:73–86.

Clark, A. E., D'Ambrosio, C., and Ghislandi, S. (2013). Poverty and well-being: Panel evidence from germany. PSE Working Papers hal-00814659, HAL.

Clark, A. E., Flèche, S., and Senik, C. (2012). The great happiness moderation. SOEPpapers on Multidisciplinary Panel Data Research 468, DIW Berlin, The German Socio-Economic Panel (SOEP).

Coelli, T., Rao, D. P., O'Donnell, C., and Battese, G. (2005). *An introduction to efficiency and productivity analysis*. Springer.

Di Tella, R. and MacCulloch, R. (2008). Gross national happiness as an answer to the Easterlin paradox? *Journal of Development Economics*, 86(1):pp. 22–42.

Diener, E. (2006). Guidelines for national indicators of subjective well-being and ill-being. *Journal of happiness studies*, 7:397 – 404.

Diener, E., Lucas, R., Schimmack, U., and Helliwell, J. (2009). *Well-being for public policy*. Oxford University Press, New York.

Fare, R., Grosskopf, S., Lovell, C., and Pasurka, C. (1989). Multilateral productivity comparison when some outputs are undesirable. *The Review of Economics and Statistics*, 71:90–98.

Fare, R., Grosskopf, S., and Lovell, C. K. (1994a). *Production Frontiers*. Cambridge University Press.

Fare, R., Grosskopf, S., Norris, M., and Zhongyang, Z. (1994b). Productivity growth, technical progress and efficiency change in industrialised countries. *American Economic Review*, 84:666–83.

Frey, B. and Stutzer, A. (2000). Happiness, economy, and institution. *Economic Journal*, 110(466):918 – 938.

George, J. and Brief, A. (1992). Feeling good - doing good: a conceptual analysis of the mood at work-organizational spontaneity relationship. *Psychological Bulletin*, 2(112):310 – 329.

Harter, J. and Schmidt, F. (2000). Validation of a performance-related and actiaction management tool: a meta-analysis and utility analysis. Technical report, Gallup Organization, Lincoln, NE.

Harter, J., Schmidt, F., and Keyes, C. (2003). Well-being in the workplace and its relationship to business outcomes: a review of the Gallup studies. In Keyes, C. and Haidt, J., editors, *Flourishing: positive psychology and the life well-lived*, pages 205 – 224. American Psychological Association, Washington, D.C.

Helliwell, J. F. (2011a). How can subjective well-being be improved. In Gorbet, F. and Sharpe, A., editors, *New Directions for Intelligent Government in Canada*, pages 283–304. Centre for the Study of Living Standards, Ottawa.

Helliwell, J. F. (2011b). Institutions as enablers of wellbeing: The Singapore prison case study. *International Journal of Wellbeing*, 1(2).

Judge, T., Thoreson, C., Bono, J., and Patton, G. (2001). The job satisfaction - job performance relationship: a qualitative and quantitative review. *Psychological Bulletin*, 127:376 – 407.

Judge, T. and Watanabe, S. (1993). Another look at the job satisfaction-life satisfaction relationship. *Journal of Applied Psychology*, 78:939 – 948.

Kahneman, D. and Krueger, A. (2006). Developments in the measurement of subjective well-being. *Journal of Economic Perspectives*, 20:3 – 24.

Keyes, C. L. M. and Magyar-Moe, J. L. (2003). The measurement and utility of adult subjective well-being. In Lopez, S. and Snyder, C., editors, *Positive psychological assessment: a handbook of models and measures*. American Psychological Association, Washington, D.C.

Krueger, A. and Schkade, D. (2008). The reliability of subjective wellbeing measures. *Journal of Public Economics*, 92(8-9):1833–1845.

Layard, R. (2005). *Happiness: Lessons from a new science*. Penguin, New York.

Malmquist, S. (1953). Index numbers and indifference surfaces. *Trabajos de Estadistica y de Investigacion Operativa*, 4(2):209–242.

Nataraja, N. and Johnson, A. (2011). Guidelines for using variable selection techniques in data envelopment analysis. *European Journal of Operational Research*, 215:662–669.

Oswald, A., Proto, E., and Sgroi, D. (2009). Happiness and productivity. *IZA Discussion Paper*, 4645.

Pastor, J., Ruiz, J., and Sirvent, I. (2002). A statistical test for nested radial dea models. *Operations Research*, 50:728–735.

Pavot, W. and Diener, E. (1993a). Review of the satisfaction with life scale. *Psychological assessment*, 5:2.

Pavot, W. and Diener, E. (1993b). Review of the satisfaction with life scale. *Psychological Assessment*, 5:164–172.

Powdthavee, N. (2007). Economics of happiness: a review of literature and applications. *Chulalongkorn Journal of Economics (forthcoming).*

Proto, E., Sgroi, D., and Oswald, A. (2010). Are happiness and productivity lower among University students with newly-divorced parents? *Warwick economic research papers*, (937).

Rogers, S., Halstead, J., Gardner, K., and Carlson, C. (2010). Examining walkability and social capital as indicators of quality of life at the municipal and neighborhood scales. *Applied research of quality of life*. DOI: 10.1007/s11482-010-9132-4.

Russell, J. E. (2008). Promoting subjective well-being at work. *Journal of Career Assessment*, 16(1):117 – 131.

Schimmack, U., Krause, P., Wagner, G., and Schupp, J. (2010). Stability and change of well-being: An experimentally enhanced latent state-trait-error analysis. *Social Indicators Research*, 95(1):19 – 31.

Schneider, L. and Schimmack, U. (2009). Self-informant agreement in well-being ratings: A meta-analysis. *Social Indicators Research*, 94(3):363–376.

Schwarz, N. and Strack, F. (1999). Reports of subjective well-being: Judgmental processes and their methodological implications. In D. Kahneman, E. D. and Schwarz, N., editors, *Well-being: the foundations of hedonist psychology.* Russell Sage Foundation, New York.

Simar, L. and Wilson, P. (1998). Sensitivity analysis of efficiency scores: How to bootstrap in non-parametric frontier modelsleast median of squares regression. *Management Science*, 44:49–68.

Simar, L. and Wilson, P. (2000a). A general methodology for bootstrapping in non-parametric frontier models. *Journal of Applied Statistics*, 27:779–802.

Simar, L. and Wilson, P. (2000b). Statistical inference in nonparametric frontier models: The state of the art. *Journal of Productivity Analysis*, 13:49–78.

Solow, R. (1957). Technical change and the aggregate production function. *Review of Economic and Statistics*, 39:312–320.

Spector, P. (1997). *Job satisfaction: application, assessment, cause and consequences*. Thousand Oaks, CA:.

Stutzer, A. and Frey, B. (2012). Recent developments in the economics of happiness: A selective overview. *Recent Developments in the Economics of Happiness: A Selective Overview. IZA Discussion Paper*, (DP 7078).

van Reekum, C., Urry, H., Johnstone, T., Thurow, M., Frye, C., Jackson, C., Schaefer, H., Alexander, A., and Davidson, R. (2007). Individual differences in amygdala and ventromedial prefrontal cortex activity are associated with evaluation speed and psychological well-being. *Journal of Cognitive Neuroscience*, 19(2):237–248.

Wanous, J. and Hudy, M. (2001). Single-item reliability: a replication and extension. *Organizational Research Methods*, 4:pp. 361 − 375.

Wright, T. and Cropanzano, R. (2000). Psychological well-being and job satisfaction as predictors of job performance. *Journal of Occupational Health Psychology*, 5:84 − 94.

Zhou, P., Ang, B., and Poh, K. (2010). Total factor carbon emission performance: a Malmquist index analysis. *Energy Economics*, 32:194–201.