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Does food security matter to subjective well-being? Evidence from a cross-country panel

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Abstract

The conventional economics literature equates welfare with consumption-based utility, neglecting the psychological effects of uncertainty and fear of the future on well-being. In this study, we examine how food insecurity relates to changes in subjective well-being within a comparative analysis across different country groups between 2005 and 2018 and find that food insecurity matters to well-being. We also examine the relationship between experienced food insecurity and well-being, taking into account any potential endogeneity. In low-income, food-deficient, food-importing and drought-affected countries, changes in the prevalence of undernourishment explain a great deal of the variation in subjective well-being over time.

KEYWORDS

country comparison, food security, subjective well-being

1 | INTRODUCTION

Between mid-2007 and March 2008 the cereal price index of the Food and Agricultural Organization (FAO) almost doubled, driven by strong increases in the prices of rice, maize, wheat and soybeans. After this dramatic peak, prices dropped rapidly to their pre-crisis levels at the end of 2008. While most commodity prices have remained relatively constant for almost 2 years, the prices of wheat, maize and soybeans sharply increased again in 2011. These price movements have been considered a major threat to global food security (von Braun & Tadesse, 2012). But what is the impact of food insecurity on people? Or, in economic terminology, what are the welfare or well-being implications of food insecurity?

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Economists measure the welfare effects (of food insecurity) using utility, a theoretical artefact that cannot be empirically observed. The utility concept does not directly relate to food insecurity, but relates only indirectly through its impact on consumption levels induced by price changes. The impact of price changes on household welfare is approximated by compensation and equivalent variation, which measures (at the old and new prices) the amount to be given to a household in order to bring it back to the utility level before the price change. Several studies have applied this concept to assess the welfare implications of 2007–2008 food crisis and concluded that the price spikes benefited producers and harmed consumers (Ivanic et al., 2012; Minot & Dewina, 2013).

Subjective well-being is a broader concept than welfare and goes beyond financial well-being. It measures life satisfaction as well as positive and negative feelings.¹ Many of these determinants are related to internal factors. Rojas and Guardiola (2017) related subjective well-being and food insecurity to three factors that go beyond (but are correlated with) the financial component: (a) sensory experiences, such as hunger pangs; (b) affective experiences, like anxiety and fear; and (c) evaluative experiences, such as relative deprivation. For instance, mental health is found to be strongly associated with food insecurity in developing countries (Weaver & Hadley, 2009). In the same vein, Bigman (1982) questioned the suitability of utility-based indicators when the stakes are as high as human casualties.

The Sustainable Development Goal (SDG) No. 3, Health and Well-Being, stipulates subjective well-being or happiness as one of the indicators of sustainable development. For instance, a lower subjective well-being worsens mental health, causes depression and anxiety, and ultimately leads to societal insecurity. All SDGs contribute to increasing well-being to some extent (De Neve & Sachs, 2020). However, in the happiness literature, SDG2, or food security, has not played an instrumental role thus far. Only a few existing studies have associated food insecurity with well-being. Diener and Tay (2015) demonstrated that individuals in countries with a higher prevalence of self-reported hunger and limited food resources exhibit a lower level of life satisfaction. Frongillo et al. (2017) and Asfahani et al. (2019) found a strong negative association between food insecurity and subjective well-being for all World Bank income classes. Due to its correlation with other drivers of well-being, ignoring a basic need like food security is likely to overestimate the influence of other variables on well-being.

One reason for neglecting food security in the happiness literature could be related to the difficulty of its measurement. Only a few holistic country-level food security indicators exist. Among these, the Global Hunger Index and the FAO prevalence of hunger are available on a regular basis. Since 2014, the FAO also collects data to calculate the Food Insecurity Experience Scale (FIES), which measures experienced food insecurity based on an eight-question scale. As an alternative to such holistic indicators, it is possible to draw on indicators of individual food security dimensions such as per capita food supply (food availability) and food price inflation (food accessibility).

Understanding the drivers of well-being is of great importance to policymakers, particularly in an unstable political environment. Dissatisfied groups or societies are more likely to become involved in civil conflict and political protest (Kim, 2018), which is rooted in the psychological relationship between life satisfaction and violent behaviour, risk-taking behaviour and people's pressing need to vent their emotions (Valois et al., 2001). Often, the correlation between poverty and dissatisfaction makes it difficult to determine the root cause of violent behaviour; however, Verhulst and Walgrave (2009) argue that agreeing with the goals of a protest does not suffice for participation. Rather, an emotional motive triggers a person's involvement. Some previous studies have related food insecurity directly to protests (e.g. Berazneva & Lee, 2013). Therefore, policy interventions aimed at improving the life satisfaction of individuals or communities can also play a role in stabilising the political environment.

The objective of the study is to contribute to three strains of literature. First, our paper contributes to the economic literature on the effects of food price shocks on well-being. In doing so, we use the life satisfaction variable of the Gallup World Poll (GWP) accounting for the psychological component of well-being as a proxy for welfare rather than simulating welfare changes based on utility theory. Second, we add to the literature on the determinants of subjective well-being at the country level by including food security as an independent variable. Last, we associate with the literature on the relationship between subjective well-being and food insecurity at the individual level.

¹Hereinafter, we use the terms well-being, subjective well-being and life satisfaction interchangeably.

We employ panel econometrics techniques at the country level over the period between 2005 and 2018. In this regard, this study is the first to examine the hypothesis that changes in average well-being, among other factors, can be attributed to food security changes. To address the potential concern that changes in the variables of interests are correlated with the changes in the other independent variables, which complicates identification of associations, we employ the a quasi-least squares dummy variables estimator (Q-LSDV) proposed by Collier and Hoeffler (2009) as a robustness check. The study approach aims to contribute to the literature by addressing the potential endogeneity between experience-based food security indicators and subjective well-being using a control function (CF) approach.

In addition, we aim at comparing the association between subjective well-being and different indicators for food security to test the hypothesis that only certain dimensions of food security are related to subjective well-being. Along with the level of undernourishment, we also consider the prevalence of severe and moderate food insecurity, extracted from the FIES, the food supply gap as a measure of calorie distribution equity in the population, as well as the indicators energy adequacy, food price inflation and food price variability. We also test the hypothesis that countries with lower levels of income are more concerned with food insecurity by employing a comparative analysis across different country types. The country types considered are based on the World Bank income classifications, FAO food security-based categories following FAO et al. (2019) and income inequality as measured by the GINI coefficient.

This paper is structured as follows. In Section 2, selected literature on subjective well-being is presented. Section 3 discusses relevant studies on the association between subjective well-being and food security. Section 4 provides an overview of the data used in the analysis and outlines the methodological approach. Then, the results and a discussion follow in Section 5. Section 6 concludes.

2 | A BRIEF SUMMARY OF THE LITERATURE ON THE DETERMINANTS OF WELL-BEING

The literature on subjective well-being is segmented into two streams—a psychological and an economic strain. Psychologists explain well-being according to an individual's emotional condition, which is affected by variables such as self-acceptance, personal growth, the purpose of life, environmental mastery, autonomy and positive relationships with others (Ryff, 1989). In his seminal contribution, Maslow (1943) arranges the psychological needs of an individual in a hierarchical order. Basic needs such as fresh air, nutrition and drinks and sleep are satisfied first and higher-level needs such individuals aspirations to self-fulfilment are only achieved by a small group of individuals.

The important economic literature focuses on the relationship between income and well-being (Deaton, 2008; Easterlin, 2008; Stevenson & Wolfers, 2008). Earlier findings, however, have not suggested the existence of any clear relationship between income and life satisfaction over time. The well-known 'Easterlin Paradox' describes the puzzling observation that happiness does not improve over time with an increasing level of income, although it is nonetheless important to describe variations within and between countries. More recent empirical evidence from new data (i.e., the GWP) challenges this conclusion by ascertaining a relationship between income and subjective well-being over time that is even stronger at higher levels of wealth (Deaton, 2008; Stevenson & Wolfers, 2008). Within the economic dimension, education, health and unemployment were found to be associated with well-being in cross-sectional studies (Blanchflower & Oswald, 2004; Deaton, 2008; Helliwell, 2003).

Aside from the importance of an individual's own income level (i.e., the absolute effect), subjective well-being is also affected by the income of other individuals with whom an individual compares him or herself (i.e., the relative effect) (Kollampambil, 2020). Hopkins (2011). provided an overview of contrasting theories. Generally, it is assumed that subjective well-being decreases with other's income, as long as the income of the other individual is greater than one's own income. The (mostly experimental) literature on social preferences (e.g., Fehr & Schmidt, 1999) posits the notion that compassion leads to a positive relationship between subjective well-being and

other's income, for other's incomes that are smaller than one's own income. The result is that people have a general dislike of inequality that may vary between societies (Alesina et al., 2004; Ferrer-i-Carbonell & Ramos, 2014).

The last large body of research has investigated the possible effects of institutions, welfare policies, and democracy on well-being (Bjørnskov et al., 2006, 2010). Institutional quality and democracy are closely related to violence and political conflict. The relationship between well-being and civil conflicts is not uni-directional. Aside from the relevance of life satisfaction to violent behaviour, as previously discussed, violence and conflict are important drivers of subjective well-being (Welsch, 2008). Welsch (2008) found that the number of conflict victims explains changes in subjective well-being over time, while the health and psychic effect outweighs the indirect income effect.

3 | HOW IMPORTANT IS FOOD SECURITY FOR WELL-BEING?

In contrast to the vast amount of literature on the determinants of subjective well-being, few studies have examined the influence of food security or its dimensions on life satisfaction, especially at the country level. Economic welfare theory supports two channels. On the one hand, higher (food) prices reduce households' purchasing power and consumption. On the other hand, food insecurity is associated with a reduction in health. Supporting the consumption channel, Alem and Köhlin (2013) discovered that the 2007–2008 food price shocks had significant adverse effects on subjective well-being in urban Ethiopia. Wolfers (2003) ascertained a negative relationship between macroeconomic variability and subjective well-being.

Apart from the indirect and long-term consequences of food security on health, Rojas and Guardiola (2017) describe the relationship between hunger and sensory and affective experiences as determining factors of mental health. Sensory experiences can be related to abdominal restlessness and hunger pangs while negative affection includes anxiety, irritation, stress and depression (Weaver & Hadley, 2009). For instance, Hadley et al. (2012) established empirically that maternal distress is related to the low nutritional status of their children. A cross-country study from sub-Saharan Africa demonstrates that social support mediates the food security impact on negative affection (Na et al., 2018).

Studies that associate food security indicators with subjective well-being are scant and mostly focus on micro-data. Diener and Tay (2015) examined at two indicators in the GWP—if households had 'gone hungry' and if they 'did not have enough money to buy food' within the preceding 12 months. They determined that a reduction in the level of these two indicators was associated with a higher level of subjective well-being in the study countries over the 2006–2013 period. Rojas and Guardiola (2017) used the same indicator and showed that hunger was related to subjective well-being, positive and negative affection, and sensory pain in their 2006 GWP sample of 88 countries.

Other relevant studies have utilised the FIES indicators, which have been included as a part of the GWP since 2014. Frongillo et al. (2017) analysed the 2014 data for 138 countries; their findings indicate that food insecurity explained both poor physical health and lower subjective well-being at the individual level. This relationship was found to hold for all World Bank income groups. Dividing the country sample into more and less-developed countries, the negative effect on experienced food insecurity was even stronger in more-developed countries (Frongillo et al., 2019). The strong negative association between food insecurity and subjective well-being between countries is confirmed in a study by Asfahani et al. (2019) among Arab youth. The authors also demonstrated that the association exists independently of the study countries' level of income and political stability. A major shortcoming of these studies is that subjective well-being and experienced food security are considered to be endogenous and exogenous variables, respectively, without accounting for their statistical dependency through their correlation with the emotional state/level of affection of the respondent at the time of the interview. To be precise, negative agitation can be expected to lead to both a lower level of current subjective life satisfaction and a more negative assessment of the past.

Last, except Rojas and Guardiola (2017), no study has previously explored the relative effect of food insecurity on well-being. Weaver and Hadley (2009) and Guardiola and Rojas (2015) discuss the fact that food security can be an indicator of social status that represents success in life, particularly in low-income settings. On the other hand, earlier studies, including Maslow (1943), argue that relative concerns are overrated and that individuals only care about their own difficulties but not those of others. By contrast, Rojas and Guardiola (2017) found that the regional prevalence of hunger was significantly negatively associated with subjective well-being, controlling for income levels and the individual's food security status. Therefore, relative concerns could play a role in the food security–well-being relationship. Specifically, reducing hunger will not only increase the subjective well-being of those being lifted out of hunger but also the well-being of the people surrounding them.

4 | ECONOMETRIC MODEL AND DATA

4.1 | How to measure food security

According to a comprehensive review of food security indicators by Pangaribowo et al. (2013), there are few multi-dimensional food security indicators available at the national level. The FAO indicator *prevalence of undernourishment* (PoU) computes the percentage of the population that is at risk of insufficient caloric consumption based on the country-level food supply, food accessibility and inequality in food accessibility.² The FIES indicator employs an individual's perception of their own food security rather than national food security statistics. The questions refer to self-reported behaviour and experiences that an individual personally endured, due to lack of money or other resources over the preceding 12 months (e.g., Frongillo et al., 2017). The questions can be composed into a global reference scale. Two of the questions are as follows:

- You ate less than you thought you should?
- You went without eating for a whole day?

and are aggregated at the country level. They are reported by the FAO as follows: The percentage of individuals that answered “Yes” to the first question is reported as the percentage of moderately food insecure and the percentage of individuals that answered “Yes” to the second question as the percentage of severely food insecure. These two FIES indicators seem to be most convincing when food security is measured against subjective well-being since they directly account for the psychological component of food insecurity. However, the prevalence of both severe and moderate food insecurity is available only for the years 2015, 2016, 2017 and 2018.

To measure the association between well-being and food security on the country level, this study employs three general food security indicators as follows: (a) the PoU, (b) the prevalence of severe food insecurity and (c) the prevalence of moderate food insecurity. In addition to the aggregate indicators, we also examine the indicators representing a single food security dimension. The national dietary energy supply adequacy represents availability, the annual growth rate of the national food price index (i.e., food price inflation) represents accessibility, and the coefficient of variation of the national food price index (i.e., food price variability) represents stability. Last, we conceptualise an indicator for inequality in the food security–food supply gap (FS gap). Specifically, we calculate the gap between the percentage of respondents that could receive an adequate energy intake (given the national energy supply) and the percentage of respondents that reported that they were moderately food secure. In other words, Equation (1) states the share of the population that reported moderate food insecurity but could be supplied with a sufficient number of calories if the distribution of the energy consumption in the country were equal.

²Other indicators are the Global Hunger Index and the Global Food Security Index that show little year-to-year variation and are not suitable for repeated cross-sectional regressions.

$$\text{FS gap}_{i,t} = \min[100, \% \text{ adequate energy supply}_{i,t}] - (1 - \% \text{ moderately food insecure}_{i,t}). \quad (1)$$

The FS gap provides an indication of the level of avoidable food insecurity and therefore can be interpreted as a measure of inequality in food supply. Given that the FS gap is measured relative to the total food supply, it does capture relative concerns with regard to food insecurity.

4.2 | Data

We use data from the World Poll of the Gallup Institute covering the years between 2005 and 2018. Since 2005, the World Poll started has been repeated annually. In total, 156 countries comprise the sample with varying frequencies of observations. The data are nationally representative for members of the adult population greater than 15 years of age, and one wave consisted of at least 1000 individuals surveyed by telephone or a face-to-face interview. In the survey, well-being is only one component; economic and socio-demographic variables comprise the other principal part (Gallup, 2018). The same questionnaire was used in all countries, so it provides a great opportunity for cross-country comparisons (Deaton, 2008).

A country's well-being is measured by the country's average Cantril ladder within 1 year. As a robustness check, we also use the Negative Experience Index.³ As control variables, we use per capita *gross domestic product (GDP)*, *share of public health expenditures*, *unemployment rate*, *domestic inflation*, the quality of *governance* and *freedom of choice* from the GWP to capture political and societal freedom. As political stability and absence of violence are one dimension of the governance indicators, we do not include another variable to separately account for violence and conflict. All in all, the control variables selected cover most of the determinants of well-being discussed in the literature review. Due to data limitations, we do not include an independent variable that captures income inequality. A complete list of the variables used is available in Table S1 in the supporting information.

The summary statistics of all of the variables are presented in Table 1. Subjective well-being measured by the Cantril ladder and freedom of choice are measured on an individual basis and represent annual, nationwide, average values. Mean life satisfaction across all countries is about 5.4, while the annual average values vary between 2.7 and 8.0. Figure 1 presents the average level of well-being across income levels since 2005 when the World Poll was first conducted. In fact, average well-being fluctuates quite substantially between survey years, for example, Germany: 6.7 (2007), -6.6 (2009), -6.9 (2013), -7.1 (2017); and Ghana: 5.2 (2007), -4.2 (2009), -4.9 (2013), -5.5 (2017).

All of the data for the food security indicators come from the Food and Agriculture Organization Statistical Database (FAOSTAT) data portal. The PoU varies between 2.5% and 55.9%. Values below 2.5% are not reported due to potential data inaccuracy. The figures represent 3-year moving averages. The report by FAO et al. (2019) also emphasises the need to distinguish between different types of countries and the respective relevance of hunger in those countries. To account for the heterogeneity between countries, we group countries based on common characteristics and run separate regressions. The grouping is based on the following variables: income level, FAO the country typology in FAO et al. (2019) and income inequality as measured by the GINI coefficient. The income groups are defined based on the World Bank's income classifications (1: high income; 2: upper middle income; 3: low income and lower middle income). The FAO classification distinguishes between (1) low-income, food-deficit countries (LIFDC), (2) net food importers, (3) countries with a high level of dependence on agriculture and (4) drought-affected countries. The GINI coefficient is used to classify countries into terciles. The full list of study countries and the categories are listed in Tables S2–S4 in the supporting information.

³The questions are as follows: Did you experience the following feelings during a lot of the day yesterday? How about physical pain/worry/sadness/stress/anger?

TABLE 1 Summary statistics

	Mean	Std. deviation	Min	Max
<i>Dependent variables</i>				
Cantril ladder	5.490392	1.137879	2.661718	8.018934
Negative experience scale	0.2637987	0.0790694	0.0954905	0.5905387
<i>Independent variables</i>				
Per capita GDP (log)	9.308854	1.165017	6.455721	11.86101
Share of public health exp. (%)	1.004556	0.7687504	-2.302585	2.230014
Freedom of choice (%)	74.07712	14.17438	25.75338	97.1135
Governance	0.0383559	.8943595	-1.771381	1.889047
Unemployment rate (log)	1.720714	.7941005	-1.298283	3.553489
Inflation (log)	3.704338	0.1180926	3.296772	4.556187
<i>Food security indicators</i>				
Undernourished (%)	9.445802	10.46977	0	54.2
Severe food insecurity (%)	8.56358	12.2886	0	63.1
Moderate food insecurity (%)	24.25662	21.83366	2.6	89
FS gap (%)	24.10187	21.28975	2.6	86
Food inflation (log)	-0.7949327	0.1461076	-3.12669	0.1304817
Food price variability (log)	-4.092399	0.7812081	-6.579211	-1.198852
Energy adequacy (%)	120.3466	14.94238	82	157

**FIGURE 1** Average well-being over time. Source: Helliwell et al. (2019) [Colour figure can be viewed at wileyonlinelibrary.com]

4.3 | Methods

4.3.1 | The standard panel model

The unit of observation in this study is country (i) per year (t). The standard fixed-effects (FE) model constructed to explain well-being (WB) can be illustrated as follows:

$$WB_{i,t} - \overline{WB}_i = \sum_j \beta_j (X_{ij,t} - \overline{X}_{ij}) + (u_i - \bar{u}_i) + (\epsilon_{i,t} - \bar{\epsilon}_i), \quad (2)$$

where $\sum_j \beta_j$ are the within-subjects estimators for the explanatory variable X_j (e.g., prevalence of undernourishment). $(u_i - \bar{u}_i)$ removes country fixed effects from the regression model and leaves the i.i.d. error term $e_{i,t} = (\epsilon_{i,t} - \bar{\epsilon}_i)$ in the estimation.

As opposed to the ordinary least squares (OLS) estimator employed by Helliwell et al. (2015), Frongillo et al. (2017), Frongillo et al. (2019), and Rojas and Guardiola (2017), the FE estimation is consistent in presence of unobserved time invariant heterogeneity but not free of costs as the impact of time-invariant factors that vary across countries but not over time is removed by the country fixed effects. Furthermore, Pluemper and Troeger (2007) and Collier and Hoeffler (2009) raised concerns regarding the estimation of rarely changing variables using a within-subjects estimator, which neglects all between-subjects variation. This is the case for many macroeconomic variables considered over a relatively short time horizon, such variables include institutional factors. Given that some of the control variables and mean differences are correlated with food security status, there is the concern that the fixed effects estimator overstates the relevance of food security for well-being by picking up variations in the other variables.

To dispel this concern, we employ an additional estimator that utilises between-subjects variation while controlling for unobserved heterogeneity. Collier and Hoeffler (2009) proposed a modified version of the least squares dummy variable (LSDV) estimator. The LSDV version by Collier and Hoeffler (2009) limits the number of dummy variables used in the regression thereby assuming essentially common fixed effects for several countries. This estimation procedure involves multiple LSDV regressions including only a subset of country dummies, which is referred to as a Q-LSDV (quasi-LSDV) estimator. Subsequently, non-significant dummy variables are eliminated and the final regression is performed including all of the remaining dummy variables.

4.3.2 | Two-step approach to self-reported food insecurity

The FIES indicators—moderate and severe food insecurity—are based on the respondents self-reporting, and therefore, both subjective well-being and self-reported food insecurity could be related to an individual's emotional state. The potential endogeneity of the FIES indicators can be addressed using a two-stage estimation approach in which we instrument self-reported food security and the FS gap. According to the traditional definition by Pearl (2000) a variable qualifies as instrument if (a) it is independent of all error terms that have influence on the outcome variable (in our case subjective well-being) which is not mediated through the endogenous variable (in our case food security) and (b) it is not independent of the endogenous variable. (a) and (b) are known as exclusion restriction and instrument relevance, respectively. The exclusion restriction does not require the outcome variable to be independent of the instrument but that the correlation is only through the instrument's influence on the endogenous variable.

We believe that the individual food security dimensions (i.e., energy adequacy, food price inflation and food price variability) are valid instruments as they affect well-being no other than through their influence on food security.⁴ However, it may be argued that there exists also a direct relationship between the instruments and the

⁴Since the food security gap is a function of energy adequacy, we replace it by PoU as the instrument for FS gap.

outcome variable. For instance, food price inflation may induce dietary changes from preferred foods to less preferred food, food price instability may create uncertainty about future food expenditures, and greater calorie availability may go along with better dietary diversity; all of which potentially affect subjective well-being not only through moderate and severe food insecurity as measured by the two questions referenced above. In such a case, the instruments may fail to meet strict exogeneity. Notwithstanding the direct correlation, which could lead to an overestimation of the effect of experienced food insecurity on subjective well-being, we believe that this would not alter the main story of the paper. First, the direct correlation between the instruments and subjective well-being—through food price inflation and dietary choices as well as energy adequacy and dietary diversity—still relates to food insecurity; even if not moderate or severe food insecurity. Second, we do not find a statistical relationship between subjective well-being and the share of calories from proteins as an indicator of dietary diversity.⁵ Last, demand theory demonstrates that the welfare impact of food price changes and food price instability is only relevant for households with a large budget share for food and high risk aversion towards food price instability (Gouel, 2014; Vu & Glewwe, 2011)—so exactly those households that will also experience moderate and severe food insecurity in consequence of a price change.

The most common instrumental variable approach is the two-stage predictor substitution approach that builds on the two-stage least squares estimator. If the first stage is a non-linear regression, it is not guaranteed that first-stage residuals are uncorrelated with the fitted values. In this case, the two-stage residual inclusion approach (also, the CF approach) is considered advantageous (Terza et al., 2008). We employ the CF approach to model the first stage as a fractional response regression that is more suitable for non-normal data bounded between 0 and 1 (Papke & Wooldridge, 1996):

$$E(fs_i|Z_i) = G(Z_i\gamma) + e_i, \quad (3)$$

where fs is the indicator of food security and Z is an instrument. $0 < G(Z_i\gamma) < 1$ for all $Z \in \mathbb{R}$ ensures that all predicted values of \hat{fs} lie in the interval (0,1). A cumulative distribution function fulfils the requirement that the predictions lie in the interval.

The residuals from the first stage e_i , which are estimated using a probit model, are included in the second stage to control for any possible endogeneity. The t test for the significance of the coefficient of the residuals in the second stage is also a direct test for the exogeneity of the independent variable. The CF approach is not common in panel settings. Mery et al. (2016) proposed running individual regressions for each survey year and using these residuals in an FE model. We follow this approach and estimate the second stage as follows:

$$WB'_{i,t} = \sum_j \beta_j X'_{ij,t} + \theta fs'_{i,t} + e'_{i,t} + \epsilon'_{i,t}, \quad (4)$$

where $(\cdot)'$ are the mean differences.

The results of the first-stage fractional response regressions are shown in Table 2. We find that all food security indicators are statistically significantly associated with food availability and food accessibility but not with stability. In the regression for the FS gap, we replace per capita energy supply with the level of undernourishment as the food security gap is computed using the difference between the percentage of people with an adequate energy intake and the prevalence of moderate food insecurity.

There is no formal testing procedure for the exclusion restriction. However, we provide an intuitive falsification test for the validity of the instruments in Table S5 of the supporting information following Di Falco et al. (2011): if

⁵Not reported in the tables but available upon request.

TABLE 2 First stage estimates: fractional response regression

	(1) 2015	(2) 2016	(3) 2017	(4) 2018
Panel A: % severely food insecure				
Food price variability (log)	-0.0609 (-1.01)	-0.0251 (-0.30)	0.0541 (0.49)	-0.0513 (-0.69)
% with adequate energy supply	-0.0285*** (-6.44)	-0.0239*** (-5.27)	-0.0263*** (-6.67)	-0.0291*** (-8.29)
Food price inflation (log)	1.375** (2.16)	1.983*** (4.88)	1.228*** (3.16)	1.018** (2.42)
N	96	94	96	96
Panel B: % moderately food insecure				
Food price variability (log)	-0.0534 (-0.79)	0.0386 (0.50)	0.0705 (0.77)	-0.0152 (-0.23)
% with adequate energy supply	-0.0294*** (-8.01)	-0.0260*** (-7.41)	-0.0280*** (-8.78)	-0.0297*** (-8.98)
Food price inflation (log)	1.547** (2.49)	2.079*** (5.13)	1.644*** (4.51)	1.291*** (2.92)
N	96	94	96	97
Panel C: % FS gap				
Food price variability (log)	-0.0743 (-1.35)	0.0596 (0.81)	-0.00663 (-0.08)	-0.0890 (-1.20)
% undernourished	0.0578*** (11.71)	0.0509*** (9.68)	0.0541*** (9.33)	0.0548*** (9.31)
Food price inflation (log)	1.432*** (3.28)	1.532*** (3.57)	1.219*** (4.47)	1.059*** (3.96)
N	96	94	96	97

Note: t statistics in parentheses.

* $p < 0.10$. ** $p < 0.05$. *** $p < 0.01$.

the instruments are invalid, they will affect the outcome variable in the second stage of the CF approach and will affect the coefficient estimates of the endogenous variables in Table 5). Table S5 of the supporting information shows that the food security dimensions cannot be considered as invalid instruments since we cannot reject their joint insignificance illustrated by F-statistics between 0.17 and 0.98. Moreover, including them into the regression model does not affect the regression coefficients.

The FIES indicators have only been included in the GWP since 2015. To analyse food security and well-being across the whole survey period, we also use a two-step approach to predict the level of severe and moderate food insecurity as well as the FS gap for the entire survey period. The predictions based on the predictor variables facilitate extrapolations beyond 2015. Table 3 presents the results from an FE regression and the corresponding relative mean squared error. In the FE regression, the coefficient of food price inflation is only moderately statistically significant. However, the predictions for moderate food insecurity and the FS gap appear to be reasonably evaluated by the relative mean squared error.

TABLE 3 Fixed-effects predictions for severe and moderate FIES and FS gap

	(1) % severely FIES	(2) % moderate FIES insecure	(3) % FS gap
Food price variability (log)	0.102 (0.74)	0.219 (0.77)	-0.0416 (-0.16)
% with adequate energy supply	-0.0736 (-1.27)	-0.198 [†] (-1.67)	
Food price inflation (log)	0.271 (0.37)	1.815 (1.21)	1.922 (1.39)
% undernourished			1.400 ^{***} (6.31)
MSE/mean	0.40	0.25	0.22
N	382	383	383

Note: *t* statistics in parentheses.

[†]*p* < 0.10. ^{**}*p* < 0.05. ^{***}*p* < 0.01.

5 | RESULTS

5.1 | Full sample: Different estimators

Table 4 shows the regression results for the whole sample of 145 countries for the FE regression model, the Q-LSDV estimator with a reduced number of country dummy variables, and a pooled OLS model without any country FE. The dummies included in the Q-LSDV were selected based on an amended version of the selection procedure by Collier and Hoeffler (2009). According to that procedure, all of the country dummies with a *p* value greater than 0.5 in Column (2) and 0.2 in Column (3) are omitted from the regression. The *p* values of the country dummies were examined in three separate regressions to limit multicollinearity between the dummy variables. The Akaike information criterion (AIC) is reported at the bottom of Table 4. As can be seen, the predictive power of the FE model slightly exceeds the performance of the Q-LSDV estimators in Columns (2) and (3), but all estimators vastly outperform the pooled OLS estimator. The difference in terms of the AIC between regressions in Column (2), which includes 121 country dummies, and (3), which includes 104 country dummies, is relatively little.

The coefficient estimates of the control variables show the right sign according to theory. The variables per capita GDP, freedom of choices, and unemployment rate are statistically significant in all of the models, although no significant relationship between inflation and well-being can be ascertained. The coefficient estimate of governance and share of public health expenditures is not statistically significantly different from zero in the FE model but in all of the other models, supporting the conjecture that the FE model fails to pick up the variation in rarely changing variables. The results of both the FE and the Q-LSDV estimators support the existing empirical evidence previously presented and confirm the findings by Helliwell et al. (2015) showing the importance of personal freedom for well-being. In addition, the estimation results support the findings of more recent studies that have ascertained a relationship between income (GDP) and well-being over time against the 'Easterlin Paradox' (e.g., Deaton, 2008; Stevenson & Wolfers, 2008). In general, the coefficient estimates of the independent variables in both the FE and Q-LSDV regressions are larger than the coefficient estimates from OLS regressions in the related literature. However, the comparison with related studies using cross-sectional data sets requires additional caution as the between variation of the independent variables is significantly larger than the within variation. Therefore, the associations between well-being and the independent variables remain significantly stronger across countries than over time.

TABLE 4 Regressions of average well-being by estimator

	(1) FE	(2) Q-LSDV	(3) Q-LSDV	(4) p.OLS
% undernourished	-0.0194** (-2.02)	-0.0125*** (-3.01)	-0.00901*** (-2.83)	-0.00959*** (-3.27)
Per capita GDP (log)	0.457** (2.43)	0.524*** (11.53)	0.506*** (16.47)	0.487*** (17.77)
Governance	0.205 (1.16)	0.273*** (4.66)	0.156*** (3.77)	0.0925*** (2.83)
Share of public health exp. (log)	-0.00287 (-0.03)	0.0938 [†] (1.80)	0.183*** (4.79)	0.308*** (9.50)
% freedom to make choices	0.00817*** (4.00)	0.00878*** (5.72)	0.0105*** (7.68)	0.0163*** (11.63)
Inflation (log)	-0.195 (-1.12)	-0.155 (-1.05)	-0.141 (-1.18)	0.00559 (0.04)
Unemployment rate (log)	-0.237*** (-3.41)	-0.222*** (-7.34)	-0.200*** (-8.03)	-0.203*** (-7.74)
Year FE	Yes	Yes	Yes	Yes
N	1465	1465	1465	1465
AIC	912.5036	1184.674	1206.771	2589.576
# dummies	—	121	104	0

Note: t statistics in parentheses; cluster robust standard errors used. Column (2) includes all country dummies with $p < 0.5$ and Column (3) with $p < 0.2$; standard errors are bootstrapped with 2500 repetitions.

* $p < 0.10$. ** $p < 0.05$. *** $p < 0.01$.

The coefficient of the main variable of interest, the PoU, is found to be negative and statistically significant in all models. Therefore, food insecurity was associated with a lower level of subjective well-being across the sample countries. The point estimate is highest in the FE model in Column (1) and lowest in the pooled OLS model in Column (4). The variation in the coefficient estimates can be partially explained by differences in the standard deviation of the variable between the different models. For instance, the within variation used for the FE model is significantly lower than the overall variation used in the pooled OLS model. Therefore, we conclude that detecting statistical significance is not favoured by the choice of model but independent of the choice of model.

In numerical terms, a 10 percentage-point reduction in the PoU was associated with an increase in subjective well-being by 0.2 on average. Given the variation in average subjective well-being across the survey period (see examples above), this might be considered quite substantial. In comparison, the magnitude of the effects of per capita GDP (10% increase leads to an increase of 0.04), unemployment rate (10% reduction leads to an increase of 0.02), and freedom of choice (10 percentage-point increase leads to an increase of 0.08) are much smaller.

5.2 | Full sample: Different food security indicators

In this section, we examine how other food security indicators, particularly, the experience-based indicators, relate to subjective well-being. By doing so, we employ the CF approach outlined above and present the second stage results that included the potentially endogenous indicators and the error terms computed from the first stage

TABLE 5 Second stage fixed-effects regression for self-reported food insecurity

Panel A: Dependent variable: Cantril ladder						
	(1)	(2)	(3)	(4)	(5)	(6)
	CF	FE	CF	FE	CF	FE
% severely food insecure	0.000954 (-0.02)					
Error % severely food insecure	-0.466 (-0.33)					
% severely food insecure Out-of-sample		-0.00605** (2.07)				
% moderately food insecure			-0.0241+ (-1.53)			
Error % moderately food insecure			-0.207 (-0.25)			
% moderately food insecure out-of-sample				-0.00316** (-2.35)		
% FS gap					-0.0292+ (-1.64)	
Error % FS gap					-0.738 (-0.64)	
% FS gap out-of-sample						-0.00576*** (-3.11)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	320	1415	321	1415	321	1446
Panel B: Dependent variable: negative experience index						
	(1)		(3)		(5)	
	CF		CF		CF	
% severely food insecure	0.00765** (2.38)					
Error % severely food insecure	0.173 (1.43)					
% moderately food insecure			0.00460*** (3.70)			
Error % moderately food insecure			0.139* (1.80)			
% FS gap					0.00364*** (2.64)	
error % FS gap					0.0319 (0.31)	
Controls	Yes		Yes		Yes	
Year FE	Yes		Yes		Yes	
N	320		321		321	

Note: *t* statistics in parentheses. Controls include per capita GDP, governance, share of public health expenditures, % freedom of choice, inflation, and unemployment rate; standard errors are bootstrapped with 500 repetitions. Columns (2), (4) and (6) use linear prediction from the regressions presented in Table 3.

+*p* < 0.15.

p* < 0.10. *p* < 0.05. ****p* < 0.01.

regression presented in Table 2. For the CF approach, we consider both subjective well-being according to the Cantril ladder (Table 5, Panel A) and the negative experience index (Table 5, Panel B).

Table 5 presents the second stage of the CF approach in Columns (1), (3) and (5), while we show the FE results based on the out of sample predictions in Columns (2), (4) and (6). For the dependent variable Cantril ladder the coefficients of moderate food insecurity and the FS gap are moderately significant at a 15% margin of error while the coefficient of severe food insecurity is statistically insignificant. Using the out-of-sample predictions as the independent variables confirms these results at even higher levels of significance. Therefore, we conclude that similar to the PoU, the indicators of experienced food insecurity are negatively associated with well-being over time. The insignificance of all the error terms in the CF approach regressions indicates a minor endogeneity issue for the Cantril ladder as the dependent variable.

This is different for the negative experience index as the dependent variable. For instance, in the regression with moderate food insecurity (Column (3) in Panel B) the coefficient of the error term is positive and significant at 90%. This observation implies that there is a correlation between reported negative experience and reported food insecurity that cannot be explained by the indicators of food security included in the first-stage regression. This is not surprising, on the contrary, we expect the emotional state of the respondent to influence her or his reporting about both negative experiences as well as about experienced food insecurity. Given this finding, future studies that employ indicators of experienced food insecurity should account for an endogeneity problem in quantitative analysis. Taking account of the endogeneity problem, we find statistical support that all indicators are positively associated with the negative experience index.

We also observe a statistically significant negative association between the FS gap, which is the measure of inequality in the food supply. High multicollinearity between the indicators renders it impossible to include both the absolute level of food security and its inequality in one model. Therefore, a final conclusion if both absolute and relative concerns matter cannot be provided. Notwithstanding, the point estimates of the supply gap are greater than those for moderate food insecurity which lends support to the hypothesis that the FS gap captures more than the absolute level of food security measured by the prevalence of moderate food insecurity.

Finally, Table 6 reveals the association of the indicators of individual food security dimensions, namely, availability, accessibility, and stability, and subjective well-being. We find that the coefficient of the percentage of adequate energy supply is positive and statically significant at 5%. For the coefficient estimate of the other indicators, we do not account for statistical significance. This is in contrast to the first-stage results for experienced food insecurity,

TABLE 6 Fixed-effects regression for individual food security dimensions

Dependent variable	(1)	(2)	(3)
Cantril ladder	FE	FE	FE
% with adequate energy supply	0.00829** (2.18)		
Food price inflation (log)		0.0503 (0.50)	
Food price variability (log)			0.0279 (1.12)
Controls	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	1434	1531	1455

Note: t statistics in parentheses. Controls include per capita GDP, governance, share of public health expenditures, % freedom of choice, inflation (not in Column (2)), and unemployment rate; standard errors are bootstrapped with 2500 repetitions.

* $p < 0.10$. ** $p < 0.05$. *** $p < 0.01$.

which demonstrated that higher food price inflation was associated with higher food insecurity. The most plausible explanation for this mismatch is that experienced food insecurity and subjective well-being have different reference periods. The Cantril ladder question asked respondents to reflect on the current situation while experienced food security referred to a 12-month period. Similarly, food inflation measures the year-to-year inflation and not necessarily the price level at the time of the interview. The same applies to the indicator for price variability. Therefore, a more accurate investigation would require the use of location and time-specific indicators.

5.3 | Country group disaggregation

To account for the possible heterogeneity between study countries, this subsection examines the relevance of food security to subjective well-being for different country groupings separately. Specifically, we examine heterogeneity with respect to income, income inequality, as well as the characteristics of the country's food sector. The details of this categorisation are presented in Tables S2–S4.

To better understand possible explanations for the significance and insignificance of the explanatory variables, we present both the food security indicators as well as the control variables in Table 7, which presents the results for the regressions according to income level. As discussed in the previous literature section, Maslow (1943) describes the role of income or wealth in explaining the level of need satisfaction desired by individuals. This may translate in differences in the importance of specific variables in countries at various levels of economic development. Table 7 is limited to the FE estimator.

The results from the FE regression show a statistical relationship between food security and subjective well-being for middle-income and low-income countries. Specifically, the coefficient estimate of the prevalence of hunger is insignificant and the coefficient of the FS gap is negative and statistically significant at 1% for middle-income countries. For low-income countries, the prevalence of hunger was negatively associated and statistically significant at 1% and the FS gap at 15%. In terms of the magnitude of the effect, a reduction in hunger by 10 percentage points was, on average, associated with a 0.3 improvement in well-being in low-income countries and a 10 percentage point reduction in the FS gap was, on average associated with a 0.1 improvement in well-being in middle-income countries.

The findings regarding the relationship between food insecurity and well-being across various income levels support earlier studies by (Asfahani et al., 2019; Frongillo et al., 2017; Frongillo et al., 2019). The estimation results are also in line with these studies with respect to the covariates income, employment and health.⁶ However, our study is different in that we find that food insecurity is a driver of subjective well-being at the country level only for countries at the low- and middle-income level. While it is possible that food insecurity in high-income countries matters for personal well-being, it seems irrelevant at the country level if only a few respondents have experienced food insecurity. In addition, time-variant changes in the level of undernourishment in high-income countries are limited or too small to be observable in the data; therefore, it is also possible that the food security indicators included may not identify the effect.

For all income classes, greater freedom of choice was associated with a higher level of subjective well-being. The coefficient estimates are in the same range for high- and middle-income countries and statistically insignificant for low-income countries. The results from the regression for high-income countries indicate that economic conditions play a critical role. The coefficient estimates for per capita GDP and the unemployment rate are statistically significant at 1% while all of the other coefficient estimates are statistically insignificant. In the regressions for middle-income countries, among the controls, unemployment rate and share of public health expenditures are positively associated with subjective well-being. The point estimate for the unemployment rate is almost double the point estimate for high-income countries. Last, the regression for low-income countries identifies some association

⁶Notably, the comparison of the coefficient estimates is difficult due to different measurement of food security.

TABLE 7 Fixed-effects regressions of average well-being by income level

Dependent variable	c(1)	c(2)	c(3)	c(4)	c(5)	c(6)
Cantril ladder	High income		Middle income		Low income	
% undernourished	0.0131 (0.26)		-0.0109 (-0.58)		-0.0306*** (-2.72)	
FS gap		-0.000698 (-0.21)		-0.0108*** (-2.87)		-0.00608 (-1.56)
Per capita GDP (log)	0.855*** (2.97)	0.845*** (2.89)	0.417 (1.02)	0.289 (0.77)	0.141 (0.45)	0.177 (0.54)
Governance	-0.136 (-0.51)	-0.145 (-0.58)	0.428 (1.16)	0.336 (1.08)	0.279 (1.01)	0.251 (0.83)
Share of public Health exp. (log)	0.0573 (0.30)	0.0427 (0.23)	0.193 (1.29)	0.285** (2.13)	-0.0801 (-0.70)	-0.0652 (-0.55)
% free to make choice	0.0113*** (3.88)	0.0114*** (3.88)	0.00886* (1.81)	0.0111** (2.41)	0.00453 (1.55)	0.00451 (1.38)
Inflation rate (log)	0.00739 (0.01)	0.00581 (0.01)	-0.0201 (-0.06)	-0.0154 (-0.05)	-0.398* (-1.70)	-0.311 (-1.29)
Unemployment rate (log)	-0.361*** (-4.01)	-0.358*** (-4.03)	-0.609*** (-3.23)	-0.633*** (-3.60)	-0.0419 (-0.44)	-0.0229 (-0.25)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	517	517	370	370	578	559
N countries	48	48	37	37	60	57

Note: *t* statistics in parentheses; cluster robust standard errors used. Standard errors are bootstrapped with 2500 repetitions.

* $p < 0.10$. ** $p < 0.05$. *** $p < 0.01$.

between subjective well-being and inflation as well as freedom of choice, while only the coefficient of inflation in Column (5) is found to be statistically significant. All of the other coefficient estimates are insignificant. Therefore, the basic need for food security is by far the most important driver of changes in subjective well-being over time in low-income countries. To briefly conclude, it is possible to observe significant differences regarding the importance of the control variables on well-being across the income levels of the countries. In some way, they provide empirical support for the hypotheses made by Maslow (1943) according to which, needs are sorted in a hierarchical order.

Table 8 presents the estimations for LIFDC, net food importers, countries with a high level of dependence on agriculture, and drought-affected countries according to the FAO definitions presented in FAO et al. (2019). The PoU was negatively associated with well-being among all of these country groups. The coefficient estimates are statistically significant for all groups except for agriculturally dependent countries, which could be related to the small sample size. The point estimates for these country groups are larger than the estimates for the low-income countries from Table 7. These findings are in line with the expectation that food security explains changes in subjective well-being in countries with a higher level of food insecurity.

Last, we investigate how the FS gap affects changes in subjective well-being across countries with different levels of income inequality. In the descriptive statistics, we observe a clear correlation between income inequality and the FS gap, which measures the inequality of a country's food supply distribution. Precisely, countries in the lower GINI tercile that have the lowest level of income inequality have, on average, an FS gap of 14%, followed by countries in the middle tercile with 27% and countries in the upper tercile with 42%. The regression results presented in Table 9 indicate that the coefficient estimate is statistically significant at the 1% and 5% levels for countries

TABLE 8 Fixed-effects regressions of average well-being by FAO classification

Dependent variable	c(1)	c(2)	c(3)	c(4)
Cantril ladder	cLIFDC	cNet importing	cAgric dependent	cDrought affected
% undernourished	-0.0350*** (-2.71)	-0.0336*** (-2.87)	-0.0275 (-1.32)	-0.0437* (-1.72)
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	376	608	184	207
N countries	39	67	20	22

Note: t statistics in parentheses. Controls include per capita GDP, governance, share of public health expenditures, % freedom of choice, inflation, and unemployment rate; standard errors are bootstrapped with 2500 repetitions.

* $p < 0.10$. ** $p < 0.05$. *** $p < 0.01$.

TABLE 9 Fixed-effects regression by GINI tercile

Dependent variable	c(1)	c(2)	c(3)
Cantril ladder	Lower	Middle	Upper
FS gap	-0.00971*** (-3.51)	0.00243 (0.56)	-0.00887** (-2.44)
Controls	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	546	394	417

Note: t statistics in parentheses. Controls include per capita GDP, governance, share of public health expenditures, % free of choices, inflation, and unemployment rate; standard errors are bootstrapped with 2500 repetitions.

* $p < 0.10$. ** $p < 0.05$. *** $p < 0.01$.

in the lower and upper tercile, respectively. The point estimates are of similar sizes. From these results, we deduce the relevance of relative concerns with regard to food security for subjective well-being. The results also dispel the concern that the association between the food supply gap and subjective well-being is solely driven by a higher level of food insecurity in countries with a greater FS gap.

6 | CONCLUDING REMARKS

The world has experienced two major food crises over the last 10 years. The economic literature has relied heavily on standard economic welfare theory to provide estimates for the welfare impact of food insecurity (e.g., Ivanic et al., 2012). However, considering findings from studies outside of the economics literature, we conclude that welfare changes can be underestimated if individuals' mental well-being is ignored. To close this research gap in the economic literature, we analyse how changes in food security relate to variations in subjective well-being.

This paper offers a comparative regression analysis based on data from the GWP, to identify differences between the drivers of well-being across different types of countries. The country types considered include: high-, middle- and low-income countries; low-income food-deficit countries, net food importers, countries with high dependence on agriculture and drought-affected countries; countries with different level of income inequality.

We find that food insecurity matters for well-being, particularly in low-income, food-deficient and drought-affected countries in which changes in food security explain a large part of the variation in subjective well-being over the observation period. This study employs a CF approach to demonstrate that experienced food insecurity causes

changes in subjective well-being and negative affection in the sample countries addressing the possible endogeneity due to the common correlation with the respondent's emotional state at the time of the interview. By employing a two-stage approach, we identify food supply and food price inflation as major drivers of experienced food insecurity.

In addition, we attempt to shed light on the importance of relative food security concerns to explain subjective well-being. For this purpose, we devise the FS gap as an indicator for inequality in the national food supply. We find that, controlling for potential endogeneity, the food supply gap is negatively associated with subjective well-being and negative affection. This is the case for countries with both low- and high-income inequality. Therefore, we conclude that next to absolute concerns over food security, individuals prefer a fair distribution of food within in their countries. However, additional research is needed to understand the extent of relative concerns more precisely.

In general, the findings of this study emphasise the fact that mental well-being is an important outcome variable of food security. Therefore, indicators of subjective well-being should be integrated into economic welfare analyses. Furthermore, the quantitative results offer a rationale for putting food security on top of the policy agenda. Several countries have already made this step by declaring the 'right to food' as a constitutional right.

These findings imply that food insecurity is a major cause of dissatisfaction in life. A low level of life satisfaction has important societal implications. Mental illness is a major health risk and mental well-being is crucial for an individual's economic productivity in both developed and developing countries. For instance, a lower well-being worsens mental health and triggers depression and anxiety. In addition, life satisfaction is positively related to political stability and therefore is a contributing factor to peace and stability.

Future research is required to fully understand the mechanisms through which food insecurity affects life satisfaction and triggers societal tensions. The role of food security for social cohesion and its implications on the economic performance of individuals and communities requires special attention.

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DATA AVAILABILITY STATEMENT

The data set and the codes used will be freely available for other researchers to use at the ZEF Data Portal.

The data that support the findings of this study will be openly available in ZEF data portal at <https://daten.zef.de/geonetwork/srv/eng/catalog.search#/home>

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