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SUPPLEMENTARY INFORMATION

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Historical analysis of national subjective wellbeing using millions of digitized books

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Supplementary Notes

Correlations between Words and Average Life satisfaction

In this section, we conduct a non-parametric analysis that complements the conventional regression analysis in the main text. First, we calculated the relative frequency of all words for which there is a valence measure for every year. The relative frequency is simply the number of times the word appears in each year t and country j in the Google book corpus data, divided by the average frequency of every word in the same language j and year t; then we select the words for which the level of correlation between the relative frequency and life satisfaction is significant at the usual threshold of the 0.05% level and calculate the averages of the valence across the words correlating positively and negatively.

If the valences of the words carry information about life satisfaction then the average valence of all words that correlate positively with life satisfaction should be significantly higher than the average valence of the words that correlate negatively. This is exactly what the bars of Supplementary Figure 3 suggest. Words that correlate positively (negatively) with life satisfaction also correlate positively (negatively) with valence. This indicates that valence is aligned with reported life satisfaction over the period for which both are available.

The Publishing Industry: Market Forces and Lags

In this section we analyse the possible channels of transmission from events like wars or reflected in GDP and life expectancy through to literature and then to the NVI. We also empirically determine plausible time lags.

The Publishing Industry

Unless we have reason to suspect some behavioural forces or market failure, economists would normally assume that firms aim to profit maximize. To put this in context, we can think of publishers as fulfilling two roles. First, they attend to the physical (and costly) production of books, which for the period in question almost entirely concerns the manufacture and distribution of printed texts: crucially they cannot publish every book they receive. This leads to their second role, filtering from the mass of submitted books those they wish to publish in order to maximize sales. In this way they act as an intermediary, taking the supply of (largely) unsolicited written books

and selecting from them books they feel will match the demand of the reading public. Recently this role has been partly carried out by "agents" who receive unsolicited manuscripts and select from those they wish to bring to the attention of publishers. Nonetheless, the end result is that only a small minority of authors end up with a publishing contract: some estimates suggest that publishers (and more recently, agents) can receive hundreds or thousands of unsolicited manuscripts a year and might select only a handful. Alberge and colleagues[1] give two specific examples of publishers' acceptances from unsolicited fiction submissions: 3/5,000 at Jonathan Cape, and 1/400 at HarperCollins. On that basis the text of published books represents a tiny proportion of the words written by all (published and unpublished) authors. The insight from economic theory is that in order to maximize profits publishers filter in a non-random way to match their choice of which books to publish with the demand from potential readers. The positive correlation we find in Figure 1 also indicates that publishers match books typified by predominantly high valence words ("happy books") to "happy people" and books typified by predominantly low valence words ("sad books") to "sad people." Later in this section we will list some quotes from publishers and authors concerning their rationale for rejecting books submitted for publication. The aim is to provide some supporting evidence for the importance of the potential demand-side to publishers.

We first need to note that there is a strong "survivor bias" when examining rejection letters: the vast majority of books that are rejected by publishers will not see print and it is highly unlikely that rejection letters for these books will come to light. The rejection letters that survive tend to be for books which become successful. What is helpful for us is that the bias works in favour of our hypothesis: if publishers are rejecting books that later do become a success on market-based grounds, it seems likely that they are rejecting many more books that never come to print on the same grounds. What follows are a few notable examples for quite famous books which hint at the importance that publishers place on the marketable nature of books and whether books are a good match for readers: note that these authors and books were eventually printed at some later date which might mean that a book was not a good match at one point but later became a better match for the market, or of course that different publishers had different ideas about what might be a good match.

The examples included here are derived from a very much longer list that can be found in[2] and directly relate

the decision to reject to demand from the reading population:

- John Gallsworthy's book "A Man of Property" from "The Forsyte Saga" was rejected on the grounds that "The author writes to please himself rather than to please the novel reading public and accordingly his novel lacks popular qualities" and that the book "would have no real sale in this country".

- Simon Brett recalled the following rejection: "I'm afraid the current state of the fiction market is too depressing for me to offer you any hope for this": this could mean that literally the market demanded depressing books but more likely it is a statement that the publisher felt that demand in the market offered no hope to Brett whose work was not a good match. Either way it supports our argument.

- Harlan Ellison recalls having a piece rejected by Playboy magazine because, while the story was "a knockout piece of writing" it did not match the philosophy of action of the "young urban male readership".

- Laurence J. Peter's book "The Peter Principle: Why Things Always Go Wrong" was rejected by McGraw-Hill in 1964 with the following words: "I can foresee no commercial possibilities for such a book and consequently can offer no encouragement".

- Stephen King remarks that he sent three chapters of a book to a publisher before he had published anything else and the rejection informed him that "We are not interested in science fiction which deals with negative utopias, they do not sell".

- Thomas Hardy's book "Tess of the D'Urbervilles" was rejected on the grounds that the readership might be concerned by "improper explicitness".

- Sherwood Anderson's book "Winesburg, Ohio" was rejected on the grounds that readers might find it "far too gloomy".

- George Moore was told about his book "Esther Waters" that it would "hardly go down here" because of certain scenes (such as childbirth) that might upset the potential readers.

- Herman Melville was told that "Moby Dick" would be "unsuitable for the Juvenille Market in [England]".
- Laurence Wylie's chronicle of French country life "A Village in the Vaucluse" was rejected on the grounds that "It is so far from being a book for the general reader that nothing can be done about it".
- Barbara Pym was told after submitting her novel "An Unsuitable Attachment": "Novels like (this), despite their qualities, are getting increasingly difficult to sell." Barbara Pym was also told of her novel "The Sweet Dove Died" that is was "Not the kind of thing to which people are turning."

Finally, note that in part A.4 of this Supplementary Material we also compare the NVI derived from the Google Books corpus with alternative indices derived from other corpora including text taken from newspapers and find that they are positively correlated. We would argue that this is not surprising as newspaper publishers are also driven by the desire to sell newspapers and so match the mood of their readers.

Different Lags of the Regressors

From the discussion above, we can argue that events happening in one year could feasibly be featured in literature in the same year (if publishers correctly predict the evolution of public mood) or with a lag of several years if publication is time-consuming or delayed. The choice of appropriate lags for the different variables we are considering then becomes an empirical question.

In what follows, we compare different models determining the channels through which a country's subjective wellbeing is factored into the different written languages based on a lag of $t - \tau$ years, with $\tau = 0, 1, 3, 5, 10$.

In Supplementary Tables 4-6 we present the estimation corresponding to the above models for life expectancy, GDP, and internal conflicts using lags 1, 3, 5 and 10. In GDP the maximal magnitude is at 5 years lag, in conflict the maximal magnitude is at a 1 year lag. For Life Expectancy, it is a bit more complicated, since it goes down after t-1, but then goes up in t-10. We preferred to use t-1 because in t-10 we lose several datapoints. From this specification the resulting lags that best explain changes in the NVI are a one-year lag for life expectancy, a five-year lag for GDP, and one-year lag for internal conflicts.

Word Stability

In this section we recalculate our main index using a set of words that have stable meanings over time. In order to identify the most stable words over time we use the following process. We use our list of ANEW words for all languages (US English, British English, Italian, German) and compute the positive pointwise mutual information (PMI) vectors using the method employed by Recchia and Louwerse[3] and initially introduced by Bullinaria and Levy.[4] For each ANEW word for every year from 1800, the PMI vector is computed as

$$PMI(x, y) = log_2(\frac{P(x, y)}{P(x)P(y)}) \tag{A-1}$$

If we wanted to calculate the PMI for the word "blossom", then x would be "blossom" and y would be every other word in the ANEW list. $P(x, y)$ would the number of times "blossom" co-occurs with all the different ANEW words divided by the total number of words in the corpus. When calculating co-occurrences we check for ANEW words which co-occur in any 2 word window either before or after word x:

worda wordb blossom wordc worde

$P(x)$ and $P(y)$ is calculated as the frequency of x and y (respectively) divided by the total number of words in the corpus. We then take the log and set any elements containing negative values to zero. Negative values, i.e. when $P(x, y) < P(x)P(y)$, indicate less than the expected number of co-occurrences, which can arise for many reasons, including a poor coverage of the represented words in the corpus. A potentially useful variation, therefore, is to set all the negative components to zero, and use only the Positive PMI.

We then see how each word changes over time and calculate the decadal changes over time using the PMI vectors we have computed for each word for every year. We take the cosine distance of word x of $year_t$ and $year_{t+10}$, where t is every year from 1800 to 2009. The cosine distance between any two elements (u, v) is defined as $\frac{1-uv}{u_2 v_2}$.

For each word, we then take all the cosine distance values and calculate the maximum difference. As an extra robustness check, we also checked that our results held when computing the average difference of the cosine distance values for each word.

Finally, in order to identify the most stable words, we take three different methods. We order all our words in terms of average difference or maximum difference and take the top 25% or top 50% where the top words are the most stable. Supplementary Table 7 shows the most stable and least stable words identified for each language.

We then recompute our new valence indices by using only the stable set of words identified and the corresponding valence scores from ANEW.

Additionally, we also test our valence indices by computing a time-locked yearly valence score for each word based on which of the top words word x has co-occurred with. Therefore, for word x, we find the top 15 words that word has co-occurred with every year. We then calculate the valence of word x in $year_t$ as the average valence of its top 15 co-occurring words.

So, taking our word "blossom", the valence for "blossom" in 1800 will be calculating using the ANEW valence from the words 'freshness', 'flourish', 'firewood', 'canvas', 'foliage', 'ripe', 'blooming', 'glossy', 'bosom', 'awning', 'badger', 'girdle', 'pristine', 'mantle', 'gallop' whereas the valence for "blossom" in 2009 will be calculated using the ANEW valence of the words 'foliage', 'blooming', 'lavender', 'magnolia', 'leaf', 'vine', 'wreath', 'fade', 'lily', 'flourish', 'spring', 'tree', 'spray', 'rot' and 'lemon.'

The results of these analyses are shown in Supplementary Tables 8-11 with related plots of the NVI using only the most stable 50% or 25% of words in Supplementary Figure 8.

Alternative Corpora and Word Norms

In this section we highlight the similarity between our reported results on the NVI based on text derived from the Google Books corpora using the ANEW word norms and variations based on alternative corpora or word norms.

Firstly in Supplementary Figure 6 we recalculate the NVI using the COHA Corpora. The Corpus of Historical American English (COHA), collected independently of the Google Books corpus, represents a balanced and representative corpus of American English containing more than 400 million words of text from 1810 to 1990, by decade, and composed of newspaper and magazine articles.[5] Also plotted in the same figure is the NVI based on the Google Book corpus. The two display a positive correlation of 0.6144 (with a p-value of 0.0051).

In Supplementary Figure 7 we once again compare our own NVI based on the Google Books corpus but this

time to an alternative derived from the “Find My Past" data from the British Library’s “British Newspaper Project" which covers 65 million newspaper and periodical articles from the UK across 200 periodicals from 1710-1953. There is a positive correlation between the two of 0.4554 (with a p-value of under 0.000). Supplementary Table 10 provides a direct comparison of the historical determinants of the two indices for the period 1820-1950.

Supplementary Tables 13 and 14 present a regression analysis of two alternative indices derived from SenticNet data, pleasantness and polarity. SenticNet is a well-known resource for sentiment analysis and offers the values for 30,000 concepts in either single word or multi-word expressions.[6] The regression analysis mirrors the analysis of the NVI in Supplementary Tables 2 and 3.

Finally, Supplementary Figure 9 presents a recalculation of the NVI using the alternative AFINN word norms rather than the ANEW word norms used in the main text. The comparison is made for British English and American English and display a positive correlation of 0.9040 and 0.7850 respectively (with p-values under 0.01).

Overview of the NVI over time

The NVI provides a first attempt to measure changes in national mood over the long-run. It also provides a way to assess how significant historical events affected national mood.

Looking at the UK some interesting patterns emerge. The NVI in the 19th century in the UK is high compared to the 20th century. The index falls with the two World Wars, and the stock market crash of 1929 and the subsequent Great Depression. In the post-World War II period the NVI reached a notable high point in 1957, the year of Harold Macmillan’s speech that most Briton’s had “never had it so good". After that the NVI falls through the 1960s and on into the 1978-79 "Winter of Discontent", with the trend rising back in the late 20th century.

Across all of the countries we consider we can see major historical events being picked up by changes in the NVI. To give a few examples: the Year of Revolutions (1848 for the European countries), the outbreak of World War I (1914 for Germany and the UK), the Wall Street Crash (1929 for the USA), Hitler takes power (1933 for Germany), the outbreak of World War II (1939 for Germany and the UK), the end of Korean War (1953 for the USA), the end of Vietnam War (1975 for the USA) and German reunification and the end of Cold War (in 1990 for all countries).

Stochastic Trends

In column 2 of Table 1 of the main text, we introduced a control for deterministic trends. However, stochastic trends may also bias our results. To address this issue we used the Augmented Dickey-Fuller unit-root test for stationarity of the NVI from 1970 onwards for all countries separately: the approach we use is typical and involves a null hypothesis defined as the presence of a unit root (a stochastic trend) and the alternative hypothesis of stationarity.

The test for a unit root can be rejected in all but Italy (MacKinnon approximate $p - value$ for $Z(t) = 0.6898$), which was integrated of order 1 (so is stationary in differences: see below). For the UK, the unit root can be rejected at 10% confidence levels (MacKinnon approximate $p - value$ for $Z(t) = 0.0696$). For these 3 countries we performed the same test on the life satisfaction variable. For life satisfaction in the UK, the test for a unit root can be strongly rejected (MacKinnon approximate $p - value$ for $Z(t) = 0.0000$). This implies that for the UK a stochastic trend is not a confounding variable in the relationship between the NVI and life satisfaction.

For life satisfaction in Italy the unit root test cannot be rejected (Italy: MacKinnon approximate $p - value$ for $Z(t) = 0.2743$), but can be rejected on the first differences; the two series are then integrated of order 1. Accordingly, there are stochastic trends in both life satisfaction and the NVI for Italy. We therefore tested for cointegration between the NVI and life satisfaction in Italy. The test for cointegration between valence and life satisfaction cannot be rejected: in the residuals of the regression of valence on life satisfaction in Italy the test allows us to reject the existence of a unit root (MacKinnon approximate $p - value$ for $Z(t) = 0.0011$). The existence of cointegration between two variables provides a further test of the existence of a link between these variables, establishing a correlation between long-term shocks in both variables. Hence a permanent shock in life satisfaction is featured in the valence as well.

In the analysis in Table 2 of the main text, we addressed the possibility that trends generated by languages, culture or other omitted factors might have biased our initial results. Here we explicitly address the possibility that omitted variables might have generated stochastic trends and biased the correlations presented above. If our estimated life satisfaction and the other regressors are integrated of order bigger than 0, this could potentially be a source of spurious correlation.

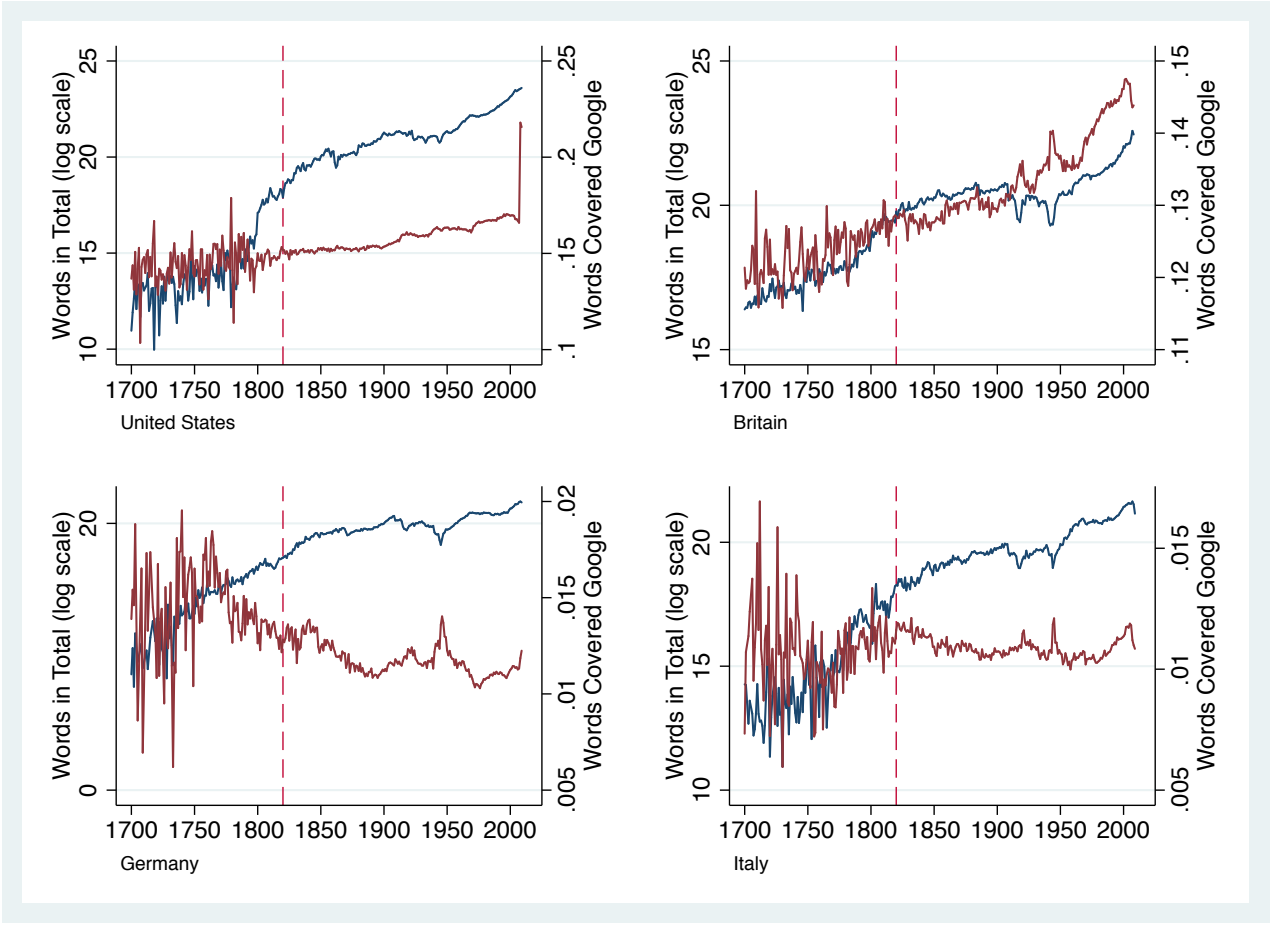
We tested the order of integration of our estimated life satisfaction for all languages and years we are considering with the Augmented Dickey-Fuller unit-root test, and we find that for all the presence of a unit root hypothesis can largely be rejected (while, as it is expected, for both GDP and life expectancy the same hypothesis cannot be rejected).

Further details of all analyses are available upon request.

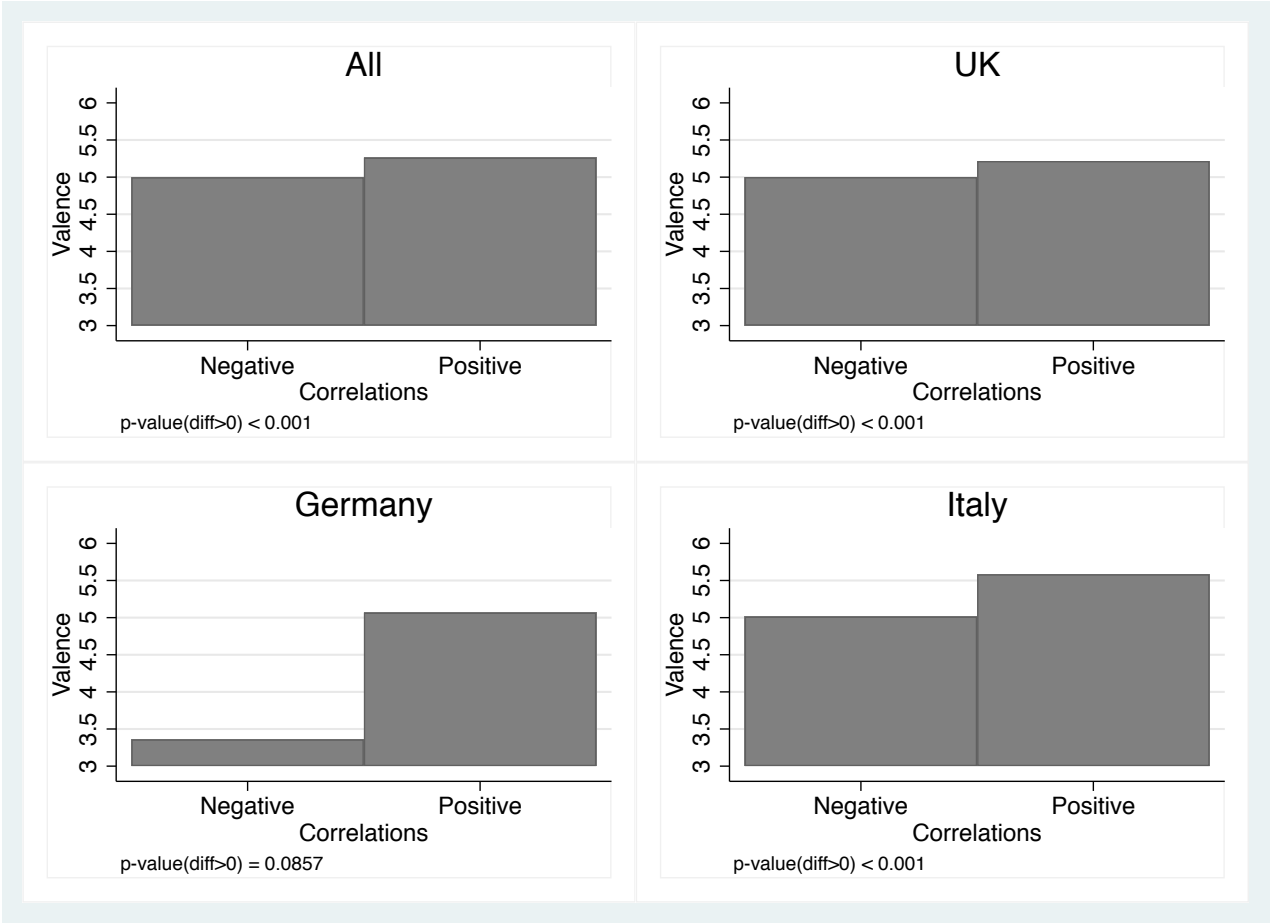
Supplementary Figures

ENGLISH	VALENCE	GERMAN	VALENCE	ITALIAN	VALENCE
aardvark	6.26	Aas	-2.6	abbaglio	3.94
abalone	5.3	Abenddämmerung	-2.35	abbandonato	2
abandon	2.84	Abendessen	2.1	abbondanza	6.82
abandonment	2.63	Abenteuer	0.81	abbraccio	7.7
abbey	5.85	Abfall	1.44	abete	6.17
abdomen	5.43	abkochen	0.4	abitante	5.67
abdominal	4.48	Abschaum	1.9	abitazione	6.46
abduct	2.42	Abscheu	-1.38	abito	7.27
abduction	2.05	Absturz	-1.6	abitudini	4.91
abide	5.52	absurd	-2.7	aborto	2.06
abiding	5.57	Abtreibung	-2.55	abuso	1.74
ability	7	aggressiv	-1.8	accettazione	5.79
abject	4	aktivieren	-0.6	accogliente	8.03
ablaze	5.15	Alarm	1.5	accomodante	6.4
able	6.64	Alimente	-0.79	accordo	6.71
abnormal	3.53	Alkoholiker	2.15	acqua	7.78
abnormality	3.05	Allee	-1.9	adorabile	7.33
abode	5.28	allein	-1.27	adulto	5.78
abolish	3.84	Allergie	-1.56	aereo	6.56
abominable	4.05	Alptraum	-1.56	affamato	4.74
abomination	2.5	anbetungswürdig	-1.22	affascinare	7.97
abort	3.1	angeekelt	0.73	affaticato	3.73
abortion	2.58	angespannt	1.53	affetto	7.48
abracadabra	5.11	Angriff	-2.1	afflizione	1.94
abrasive	4.26	ängstlich	1	affogare	1.79
abreast	4.62	Anreiz	-1.93	aggressione	2.53
abrupt	3.28	Anstellung	-2.21	aggressivo	3.48

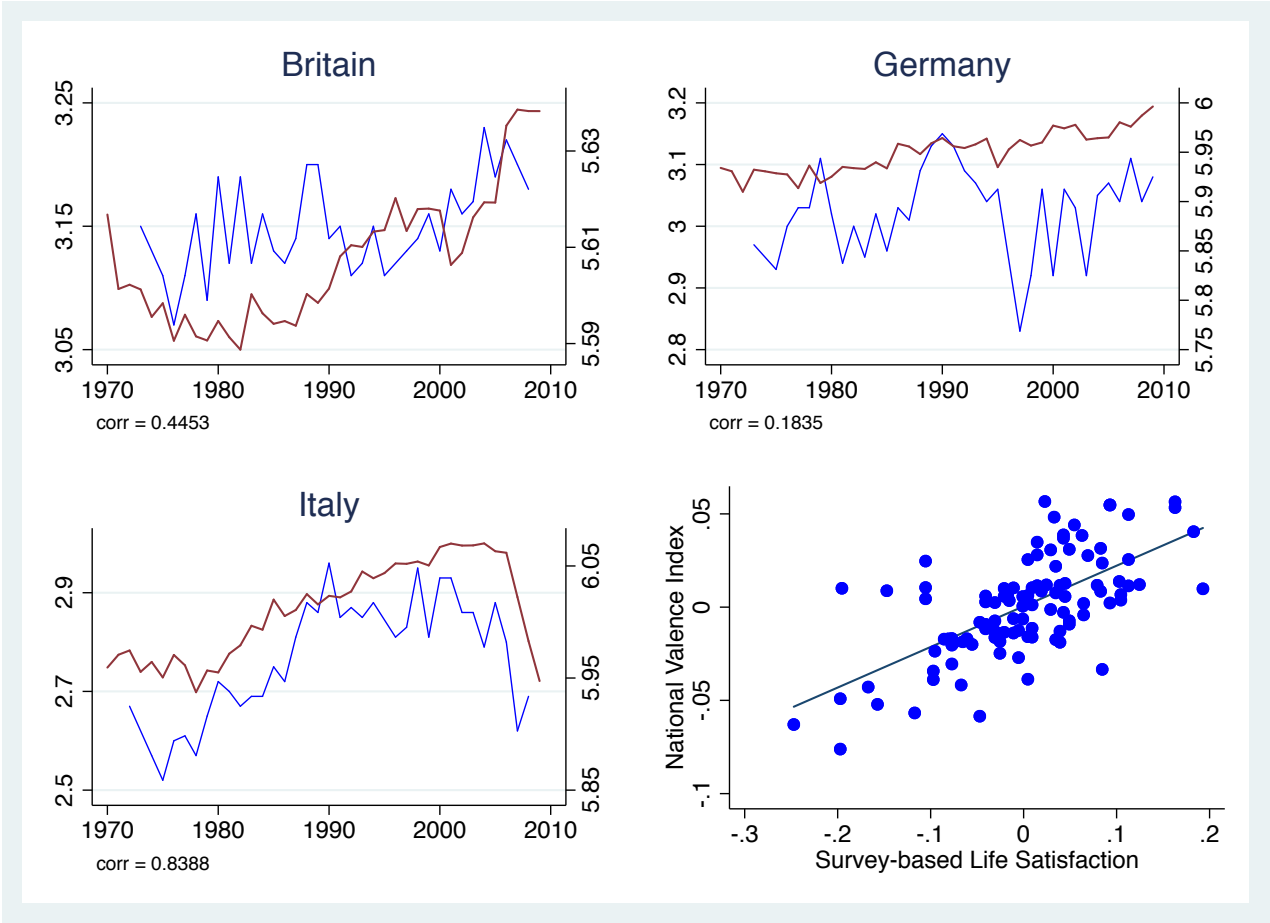
Supplementary Figure 1: **A Sample of Word Valence in Different Languages.** For English and Italian the words are scaled from 1 to 9. For Germany the valence ratings were collected on a -3 to +3 scale. The German mean values were adjusted to reflect a 1 to 9 scale in our analysis.



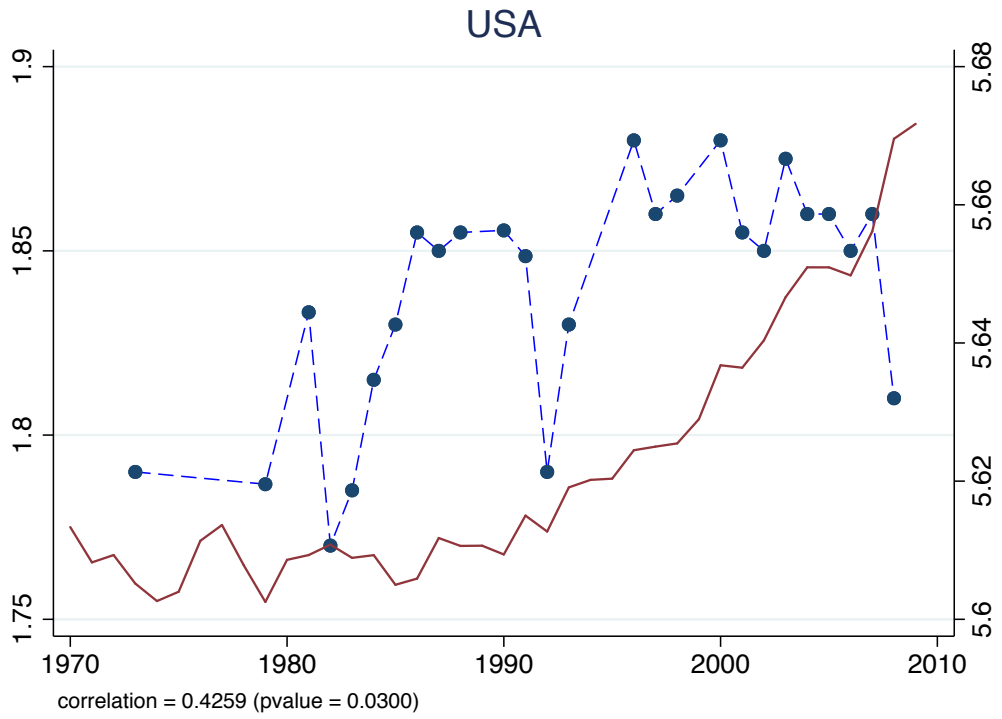
Supplementary Figure 2: **The Number of Words and Share of Words Covered.** The red line represents the proportion of words in the corpus covered in the text analysis by the valence norms and the blue line represents the total number of words—in logarithmic scale—for all countries considered in the analysis.



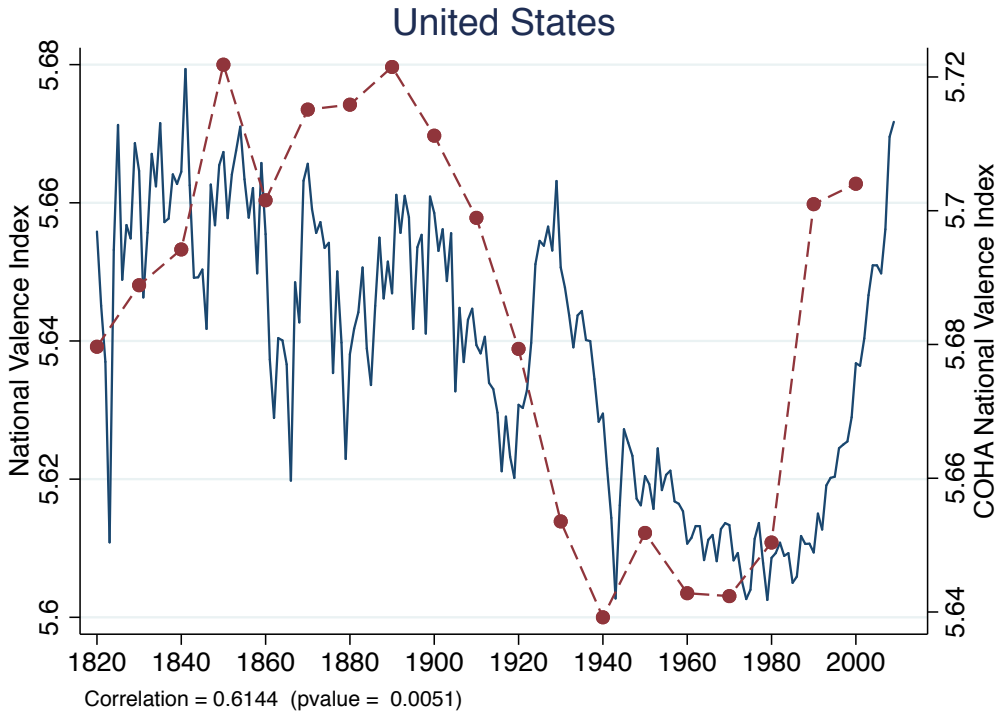
Supplementary Figure 3: **Average Valence and Correlations with Life Satisfaction: All Countries Available.** We selected the words in our dataset for which the level of correlation between valence and life satisfaction (from the Eurobaromter survey-based measure) is significant at the 0.05% level and then calculated the averages of the valence across the words correlating positively and negatively for the UK, Germany and Italy. The bars in the figure represent the average valence of words that correlate positively and negatively. By looking at the bars it is possible to see that the average valence among words that correlate positively with life satisfaction is higher than the average valence among words that correlate negatively with life satisfaction.



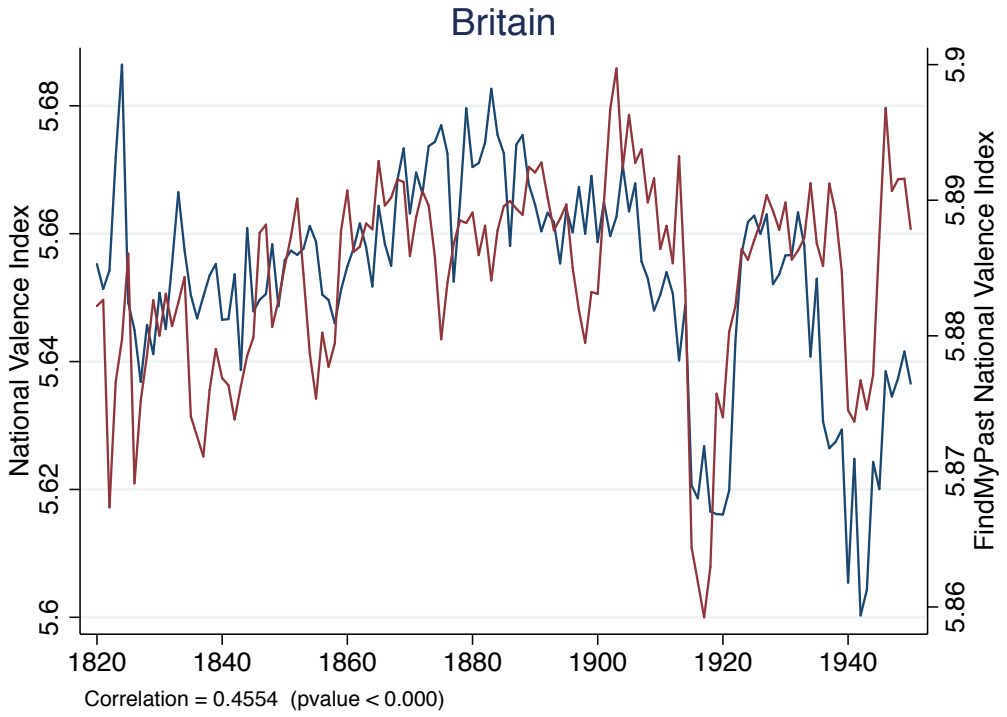
Supplementary Figure 4: **The National Valence Index and Aggregate Life Satisfaction.** In the first 3 panels which present time-series data, the National Valence Index is represented in red (values in the left axis) and life satisfaction is represented in blue (values in the right axis). In the last panel, we plotted the National Valence Index against life satisfaction for the same countries and periods; both variables are expressed in the form of residuals after controlling for country fixed-effects.



Supplementary Figure 5: **The National Valence Index and Aggregate Life Satisfaction in the US.** The National Valence Index is represented in red (values on the left axis) and life satisfaction is represented in blue (values on the right axis). Life Satisfaction data are from the World Database of Happiness[7] and are coded as 1 (= “disatisfied") and 2 (= “satisfied"). They are available only for the years 1973, 1979, 1981-1993, 1996-1998 and 2000-2008.

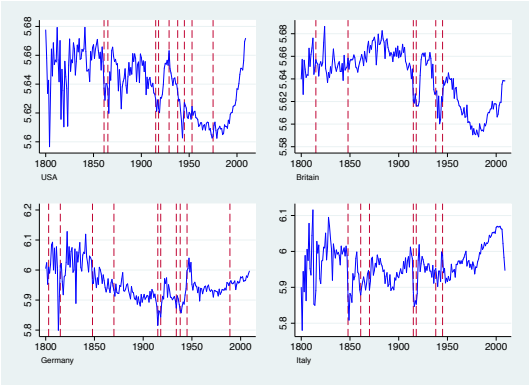


Supplementary Figure 6: **The National Valence Index Derived from Two Different Corpora of US Data.** The red line represents the National Valence Index calculated using the COHA Corpora - based on 400 million words of text from 1810 to 1990, by decade, and composed of newspaper and magazine articles. The blue line represents the US National Valence Index derived from the Google Books corpus.

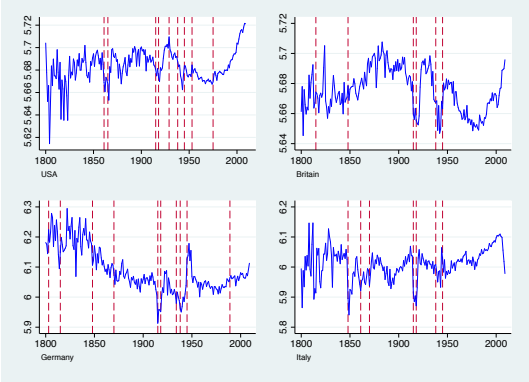


Supplementary Figure 7: **The National Valence Index Derived from Two Different Corpora of British Data.** The red line represents the National Valence Index calculated using FindMyPast data - based on 200 British periodicals from 1820-1953. The blue line represents the British National Valence Index derived from the Google Books corpus.

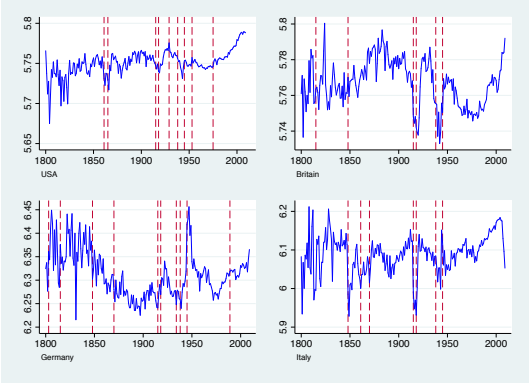
National Valence Index.



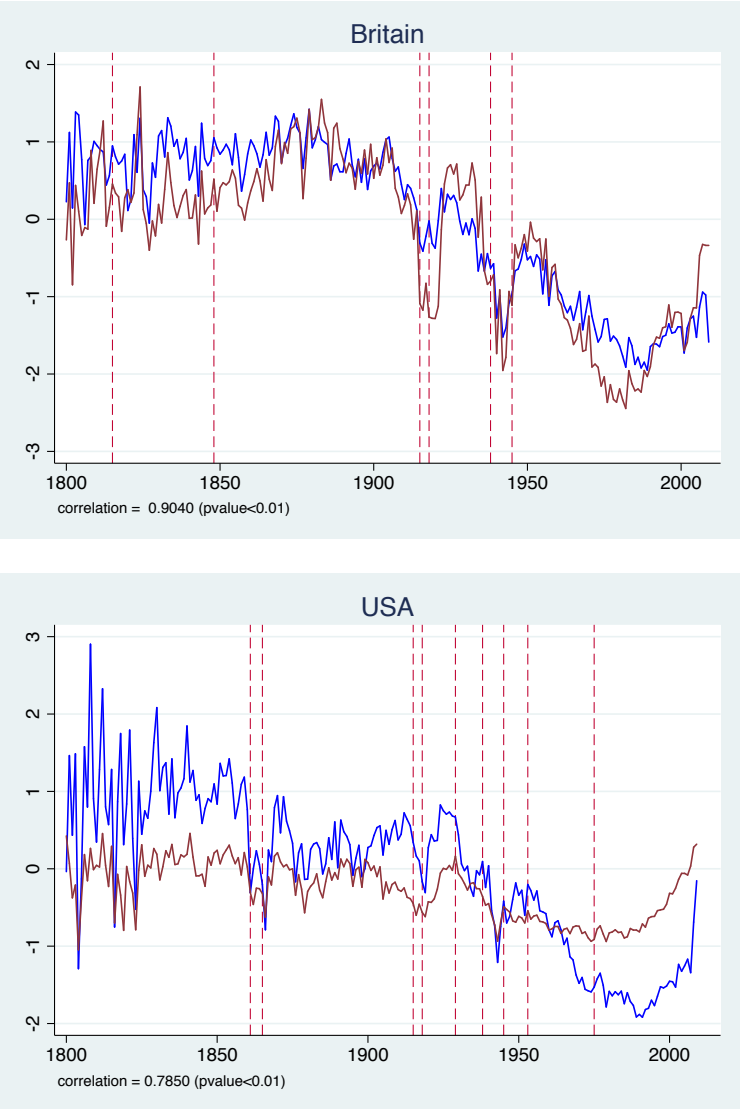
National Valence Index Using the Top 50% Most Stable Words.



National Valence Index Using the Top 25% Most Stable Words.



Supplementary Figure 8: **A Time-Series Plot Over the Period 1800-2009.**



Supplementary Figure 9: **The NVI Derived from the AFINN Word Norm vs the ANEW Word Norm over the Period 1800-2009.** The blue line represents the National Valence Index derived from the AFINN word norm and the red line the National Valence Index derived from the ANEW word norm. The National Valence Indices are transformed in standard deviations to ease comparability.

Supplementary Tables

Supplementary Table 1: **Main Variables.** These are the mean, standard deviation, minimum value and maximum value of the key variables described in the main text.

Variable	Mean	Std. Dev.	Min.	Max.	N
National Valence Index	5.798	0.164	5.589	6.128	760
FindMyPast National Valence Index	5.884	0.007	5.859	5.9	131
COHA National Valence Index	5.685	0.029	5.639	5.722	19
Life Satisfaction	2.98	0.181	2.52	3.23	104
Life Satisfaction (US)	1.835	0.033	1.77	1.88	28
per capita GDP (Maddison)	11980.032	11270.36	400	50902	728
per capita GDP (Penn)	25233.999	7193.752	13069.197	43511.594	170
Life Expectancy	61.457	14.088	25.81	82.400	493
Internal Conflict	0.097	0.296	0	1	762
Democracy	5.649	5.894	-9	10	624
Education Inequality	31.526	22.722	6.111	98.935	504
Words Covered Google	0.079	0.068	0.01	0.218	759
Words Covered FindMyPast	0.016	0.001	0.015	0.018	131

Supplementary Table 2: **Differences in the National Valence Index Regressed on Differences in Aggregate Life Satisfaction.** The dependent variable is the difference between two consecutive years in the average life satisfaction per country taken from the Eurobarometer survey-based measure. Simple OLS estimator. The period covered is 1973 to 2009, the period over which both measures exist. The countries considered are Germany, Italy and the UK, the three countries for which both data exist. Per Capita GDP (expressed in terms of purchasing power parity) is from the PWT 8.0 dataset. Both regressions includes year fixed-effects (to help deal with spurious correlations over time). SE = standard error of the mean and p = p-value.

	1 Year FE b/se/p	2 Year FE+GDP b/se/p
NVI(t)-NVI(t-1)	1.2440	1.2638
	(SE= 0.7146)	(SE=0.7334)
	(p= 0.0868)	(p= 0.0901)
Log GDP(t)-Log GDP(t-1)		–0.0774
		(SE= 0.5348)
		(p = 0.8855)
Year FE	Yes	Yes
r2	0.308	0.308
N	95	95

Supplementary Table 3: **Historical Determinants of the National Valence Index – all coefficients are visible.** The countries are Germany, Italy, UK and the United States and the period considered is 1820-2009. The regressions are estimated with an OLS country fixed-effects estimator and either a year fixed-effect (to help deal with spurious correlations over time) or country fixed-effect (to help deal with spurious correlations across countries). Robust standard errors clustered at country levels are given in brackets. SE = standard error of the mean and p = p-value.

	1 Year FE b/se/p	2 Year FE b/se/p	3 Year FE b/se/p	4 CS Trends b/se/p
(log) GDP(t-5)	0.0826		0.0698	0.0550
	(SE=0.0090)		(SE=0.0106)	(SE=0.0130)
	(p=0.0027)		(p=0.0072)	(p=0.0240)
Life Expectancy(t-1)		0.0048	0.0030	0.0016
		(SE=0.0013)	(SE=0.0014)	(SE=0.0013)
		(p=0.0328)	(p=0.1187)	(p=0.2951)
Internal Conflict(t-1)				–0.0184
				(SE=0.0040)
				(p=0.0188)
Words Covered	–1.5813	–2.0859	–1.2282	0.4901
	(SE=1.3370)	(SE=2.2393)	(SE=1.3712)	(SE=0.7027)
	(p=0.3221)	(p=0.4203)	(p=0.4364)	(p=0.5357)
Democracy	0.0030	0.0024	0.0021	–0.0006
	(SE=0.0010)	(SE=0.0008)	(SE=0.0005)	(SE=0.0006)
	(p=0.0575)	(p=0.0620)	(p=0.0245)	(p=0.3339)
Education Inequality	0.0003	0.0008	0.0004	0.0001
	(SE=0.0003)	(SE=0.0002)	(SE=0.0001)	(SE=0.0002)
	(p=0.4050)	(p=0.0181)	(p=0.0341)	(p=0.6943)
Italy Trend				–0.0009
				(SE=0.0007)
				(p=0.2670)
Germany Trend				–0.0007
				(SE=0.0006)
				(p=0.3557)
UK Trend				–0.0016
				(SE=0.0005)
				(p=0.0484)
USA Trend				–0.0018
				(SE=0.0006)
				(p=0.0629)
Year FE	Yes	Yes	Yes	No
r2	0.752	0.705	0.774	0.571
N	412	412	412	412

Supplementary Table 4: **Effect of Life Expectancy on the National Valence Index, using Different Time Lags in the Regressors.** The dependent variable is the NVI at time t. OLS with country fixed-effects estimator. The countries included are Germany, Italy, UK and the United States and the period considered is 1820-2009. This table highlights the significance level of different possible lags of Life Expectancy. Robust standard errors are clustered at country levels are given in brackets. SE = standard error of the mean and p = p-value.

	1 M1 b/se/p	2 M2 b/se/p	3 M3 b/se/p	4 M4 b/se/p	5 M5 b/se/p
Life Expectancy(t)	0.0046 (SE=0.0013) (p=0.0354)				
Life Expectancy(t- 1)		0.0048 (SE=0.0013) (p=0.0328)			
Life Expectancy(t- 3)			0.0044 (SE=0.0008) (p=0.0132)		
Life Expectancy(t- 5)				0.0027 (SE=0.0010) (p=0.0717)	
Life Expectancy(t- 10)					0.0049 (SE=0.0007) (p=0.0050)
Democracy(t)	0.0026 (SE=0.0011) (p=0.0913)	0.0024 (SE=0.0008) (p=0.0620)	0.0029 (SE=0.0009) (p=0.0529)	0.0035 (SE=0.0010) (p=0.0378)	0.0026 (SE=0.0010) (p=0.0724)
Education Inequality(t)	0.0009 (SE=0.0002) (p=0.0158)	0.0008 (SE=0.0002) (p=0.0181)	0.0008 (SE=0.0002) (p=0.0195)	0.0008 (SE=0.0002) (p=0.0328)	0.0007 (SE=0.0003) (p=0.0937)
Words Covered(t)	–2.0159 (SE=2.2155) (p=0.4300)	–2.0859 (SE=2.2393) (p=0.4203)	–1.9190 (SE=2.2140) (p=0.4499)	–2.2976 (SE=2.4087) (p=0.4105)	–1.8185 (SE=2.1879) (p=0.4669)
Year FE	Yes	Yes	Yes	No	No
r2	0.696	0.705	0.699	0.672	0.698
N	412	412	408	404	394

Supplementary Table 5: **Effect of the GDP on the National Valence Index, using Different Time Lags in the Regressors.** The dependent variable is the NVI at time t. OLS with country fixed-effects estimator. The countries included are Germany, Italy, UK and the United States and the period considered is 1820-2009. This table highlights the significance level of different possible lags of GDP. Robust standard errors clustered at country levels are given in brackets. SE = standard error of the mean and p = p-value.

	1 M1 b/se/p	2 M2 b/se/p	3 M3 b/se/p	4 M4 b/se/p	5 M5 b/se/p
(log) GDP(t)	0.0614				
	(SE=0.0072)				
	(p=0.0034)				
(log) GDP(t-1)		0.0611			
		(SE=0.0079)			
		(p=0.0046)			
(log) GDP(t-3)			0.0659		
			(SE=0.0081)		
			(p=0.0039)		
(log) GDP(t-5)				0.0735	
				(SE=0.0111)	
				(p=0.0071)	
(log) GDP(t-10)					0.0728
					(SE=0.0079)
					(p=0.0027)
Democracy(t)	0.0025	0.0026	0.0028	0.0029	0.0027
	(SE=0.0010)	(SE=0.0010)	(SE=0.0010)	(SE=0.0010)	(SE=0.0010)
	(p=0.0786)	(p=0.0763)	(p=0.0647)	(p=0.0578)	(p=0.0645)
Education Inequality(t)	0.0004	0.0004	0.0004	0.0003	0.0002
	(SE=0.0002)	(SE=0.0002)	(SE=0.0002)	(SE=0.0002)	(SE=0.0003)
	(p=0.1287)	(p=0.1366)	(p=0.1766)	(p=0.2670)	(p=0.5048)
Words Covered(t)	–2.5082	–2.4601	–2.2927	–2.1053	–2.1659
	(SE=1.4543)	(SE=1.4147)	(SE=1.2709)	(SE=1.0832)	(SE=1.0778)
	(p=0.1830)	(p=0.1804)	(p=0.1690)	(p=0.1472)	(p=0.1381)
Year FE	Yes	Yes	Yes	Yes	Yes
r2	0.707	0.707	0.718	0.735	0.728
N	459	459	459	459	459

Supplementary Table 6: **The Effect of Internal Conflicts on the National Valence Index, using Different Time Lags in the Regressors.** The dependent variable is the NVI at time t. OLS with country fixed-effects estimator. The countries are Germany, Italy, UK and the United States. This table highlights the significance level of different possible lags of Internal Conflict. Robust standard errors clustered at country levels are given in brackets. SE = standard error of the mean and p = p-value.

	1 M1 b/se/p	2 M2 b/se/p	3 M3 b/se/p	4 M4 b/se/p	5 M5 b/se/p
Internal Conflict(t)	–0.0372 (SE=0.0161) (p=0.1036)				
Internal Conflict(t-1)		–0.0393 (SE=0.0133) (p=0.0594)			
Internal Conflict(t-3)			–0.0316 (SE=0.0090) (p=0.0392)		
Internal Conflict(t-5)				–0.0278 (SE=0.0064) (p=0.0224)	
Internal Conflict(t-10)					–0.0224 (SE=0.0072) (p=0.0523)
Words Covered(t)	0.0380 (SE=1.5854) (p=0.9824)	–0.0161 (SE=1.5378) (p=0.9923)	0.0231 (SE=1.5244) (p=0.9889)	–0.0876 (SE=1.4500) (p=0.9556)	–0.4527 (SE=1.3528) (p=0.7599)
r2	0.008	0.010	0.006	0.005	0.006
N	1227	1223	1215	1207	1187

Supplementary Table 7: **The Most Stable and Least Stable Words for each Language, for Words that Existed in 1800.**

Language	Most stable words	Least stable words
UK English	hugger, can, would, will, may	daybreak, daresay, daisy, banter, irrigate
USA English	can, will, would, shall, hundred	stairs, staircase, stainless, sportsman, holly
German	frühling, räuber, liebe, gesundheit, gott	schlüssel, schnee, vogel, sauer, heu
Italian	regina, santo, colore, lago, ferro	saggio, salice, salutare, ratto, gelosia

Supplementary Table 8: **Historical Determinants of the National Valence Index (valence computed using the 50% most stable words identified using the maximum difference in cosine distances), from 1820 to 2009.** OLS with country fixed-effects estimator. SE = standard error of the mean and p = p-value.

	1 Year FE b/se/p	2 Year FE b/se/p	3 Year FE b/se/p	4 CS Trends b/se/p
(log) GDP(t-5)	0.0669		0.0507	0.0488
	(SE=0.0138)		(SE=0.0152)	(SE=0.0087)
	(p=0.0167)		(p=0.0446)	(p=0.0110)
Life Expectancy(t-1)		0.0048	0.0032	0.0024
		(SE=0.0007)	(SE=0.0010)	(SE=0.0016)
		(p=0.0066)	(p=0.0524)	(p=0.2311)
Internal Conflict(t-1)				–0.0134
				(SE=0.0011)
				(p=0.0012)
Words Covered	0.2436	0.3088	0.2814	0.9849
	(SE=0.6590)	(SE=0.6382)	(SE=0.6851)	(SE=0.4898)
	(p=0.7362)	(p=0.6616)	(p=0.7088)	(p=0.1379)
Democracy	0.0024	0.0017	0.0013	–0.0008
	(SE=0.0004)	(SE=0.0008)	(SE=0.0002)	(SE=0.0006)
	(p=0.0126)	(p=0.1086)	(p=0.0134)	(p=0.2781)
Education Inequality	0.0001	0.0005	0.0002	0.0001
	(SE=0.0002)	(SE=0.0001)	(SE=0.0001)	(SE=0.0002)
	(p=0.7621)	(p=0.0237)	(p=0.1036)	(p=0.5709)
Italy Trend				–0.0011
				(SE=0.0007)
				(p=0.1920)
Germany Trend				–0.0009
				(SE=0.0006)
				(p=0.2314)
UK Trend				–0.0015
				(SE=0.0005)
				(p=0.0716)
USA Trend				–0.0016
				(SE=0.0006)
				(p=0.0767)
Year FE	Yes	Yes	Yes	No
r2	0.691	0.673	0.725	0.464
N	412	412	412	412

Supplementary Table 9: **Historical Determinants of the National Valence Index (valence computed using the 25% most stable words identified using the maximum difference in cosine distances), from 1820 to 2009.** OLS with country fixed-effects estimator. SE = standard error of the mean and p = p-value.

	1 Year FE b/se/p	2 Year FE b/se/p	3 Year FE b/se/p	4 CS Trends b/se/p
(log) GDP(t-5)	0.0514		0.0375	0.0492
	(SE=0.0084)		(SE=0.0119)	(SE=0.0078)
	(p=0.0087)		(p=0.0507)	(p=0.0079)
Life Expectancy(t-1)		0.0041	0.0030	0.0026
		(SE=0.0010)	(SE=0.0011)	(SE=0.0019)
		(p=0.0249)	(p=0.0761)	(p=0.2605)
Internal Conflict(t-1)				–0.0102
				(SE=0.0021)
				(p=0.0175)
Words Covered	0.9801	1.0423	0.6331	1.2139
	(SE=0.7372)	(SE=0.9230)	(SE=0.5019)	(SE=0.6098)
	(p=0.2757)	(p=0.3409)	(p=0.2963)	(p=0.1406)
Democracy	0.0015	0.0008	0.0005	–0.0009
	(SE=0.0005)	(SE=0.0008)	(SE=0.0004)	(SE=0.0006)
	(p=0.0522)	(p=0.3587)	(p=0.2771)	(p=0.2665)
Education Inequality	0.0002	0.0005	0.0003	0.0003
	(SE=0.0001)	(SE=0.0001)	(SE=0.0001)	(SE=0.0002)
	(p=0.1462)	(p=0.0188)	(p=0.1029)	(p=0.2623)
Italy Trend				–0.0012
				(SE=0.0007)
				(p=0.1815)
Germany Trend				–0.0011
				(SE=0.0007)
				(p=0.2180)
UK Trend				–0.0013
				(SE=0.0005)
				(p=0.0915)
USA Trend				–0.0015
				(SE=0.0006)
				(p=0.0975)
Year FE	Yes	Yes	Yes	No
r2	0.671	0.673	0.703	0.408
N	412	412	412	412

Supplementary Table 10: **Historical Determinants of the National Valence Index (valence computed using the 25% most stable words identified using the average difference in cosine distances), from 1820 to 2009.** OLS with country fixed-effects estimator. SE = standard error of the mean and p = p-value.

	1 Year FE b/se/p	2 Year FE b/se/p	3 Year FE b/se/p	4 CS Trends b/se/p
(log) GDP(t-5)	0.0921		0.0708	0.0543
	(SE=0.0201)		(SE=0.0191)	(SE=0.0135)
	(p=0.0195)		(p=0.0340)	(p=0.0278)
Life Expectancy(t-1)		0.0064	0.0043	0.0023
		(SE=0.0008)	(SE=0.0009)	(SE=0.0019)
		(p=0.0034)	(p=0.0177)	(p=0.3124)
Internal Conflict(t-1)				–0.0145
				(SE=0.0037)
				(p=0.0287)
Words Covered	0.5820	0.6227	0.4637	0.8523
	(SE=0.5977)	(SE=0.6138)	(SE=0.6590)	(SE=0.6286)
	(p=0.4020)	(p=0.3850)	(p=0.5324)	(p=0.2682)
Democracy	0.0042	0.0034	0.0027	–0.0003
	(SE=0.0005)	(SE=0.0009)	(SE=0.0002)	(SE=0.0006)
	(p=0.0033)	(p=0.0290)	(p=0.0008)	(p=0.6889)
Education Inequality	0.0003	0.0009	0.0004	0.0002
	(SE=0.0004)	(SE=0.0003)	(SE=0.0002)	(SE=0.0002)
	(p=0.5949)	(p=0.0527)	(p=0.0816)	(p=0.2270)
Italy Trend				–0.0009
				(SE=0.0009)
				(p=0.4005)
Germany Trend				–0.0011
				(SE=0.0008)
				(p=0.2755)
UK Trend				–0.0016
				(SE=0.0007)
				(p=0.1083)
USA Trend				–0.0018
				(SE=0.0008)
				(p=0.1071)
Year FE	Yes	Yes	Yes	No
r2	0.739	0.711	0.780	0.605
N	412	412	412	412

Supplementary Table 11: **Historical Determinants of the National Valence Index (time-locked valences computed using the valence of the 50% most stable words, identified using the maximum difference in cosine distances, based on their co-occurence with the observed word), from 1820 to 2009.** OLS with country fixed-effects estimator. SE = standard error of the mean and p = p-value.

	1 Year FE b/se/p	2 Year FE b/se/p	3 Year FE b/se/p	4 CS Trends b/se/p
(log) GDP(t-5)	0.0470		0.0394	0.0362
	(SE=0.0101)		(SE=0.0101)	(SE=0.0146)
	(p=0.0187)		(p=0.0298)	(p=0.0890)
Life Expectancy(t-1)		0.0027	0.0015	0.0029
		(SE=0.0007)	(SE=0.0010)	(SE=0.0010)
		(p=0.0315)	(p=0.2282)	(p=0.0609)
Internal Conflict(t-1)				–0.0069
				(SE=0.0042)
				(p=0.1957)
Words Covered	1.1891	1.2274	1.2068	0.2085
	(SE=0.6269)	(SE=0.6296)	(SE=0.6328)	(SE=0.3967)
	(p=0.1541)	(p=0.1464)	(p=0.1526)	(p=0.6356)
Democracy	0.0018	0.0016	0.0012	0.0007
	(SE=0.0008)	(SE=0.0007)	(SE=0.0010)	(SE=0.0006)
	(p=0.1165)	(p=0.1160)	(p=0.2952)	(p=0.3597)
Education Inequality	–0.0006	–0.0002	–0.0005	–0.0004
	(SE=0.0001)	(SE=0.0001)	(SE=0.0002)	(SE=0.0003)
	(p=0.0277)	(p=0.1866)	(p=0.0464)	(p=0.2035)
Italy Trend				–0.0022
				(SE=0.0007)
				(p=0.0571)
Germany Trend				–0.0020
				(SE=0.0006)
				(p=0.0424)
UK Trend				–0.0020
				(SE=0.0006)
				(p=0.0453)
USA Trend				–0.0022
				(SE=0.0006)
				(p=0.0314)
Year FE	Yes	Yes	Yes	No
r2	0.547	0.526	0.554	0.299
N	412	412	412	412

Supplementary Table 12: **Comparing Historical Determinants of the National Valence Indices from 1820 to 2009 in Britain, using Find My Past Data and Google**. The NVI are transformed in standard deviations to ease comparability. OLS with country fixed-effects estimator. SE = standard error of the mean and p = p-value.

	1820-1950 FindMyPast b/se	1820-1950 Google b/se
GDP (log) t	0.9149***	
	(SE=0.1512)	
	(p=0.0000)	
GDP (log) t-5		0.6519**
		(SE=0.2654)
		(p=0.0154)
WW1	–2.1139***	–1.0180***
	(SE=0.2163)	(SE=0.2439)
	(p=0.0000)	(p=0.0001)
WW2	–1.4433***	–1.0039***
	(SE=0.2171)	(SE=0.2570)
	(p=0.0000)	(p=0.0002)
Words Covered(t)	146.1456	–139.5449***
	(SE= 101.3410)	(SE = 34.2593)
	(p=0.0001)	(p=0.1518)
r2	0.529	0.486
N	130	130

Supplementary Table 13: **Historical Determinants using SenticNet Pleasantness from 1820 to 2009.** OLS with country fixed-effects estimator. SE = standard error of the mean and p = p-value.

	1 Year FE b/se/p	2 Year FE b/se/p	3 Year FE b/se/p	4 CS Trends b/se/p
(log) GDP(t-5)	0.0224		0.0166	0.0002
	(SE=0.0062)		(SE=0.0056)	(SE=0.0020)
	(p=0.0368)		(p=0.0601)	(p=0.9117)
Life Expectancy(t-1)		0.0017	0.0012	0.0002
		(SE=0.0001)	(SE=0.0003)	(SE=0.0003)
		(p=0.0014)	(p=0.0249)	(p=0.5507)
Internal Conflict(t-1)				0.0020
				(SE=0.0036)
				(p=0.6203)
Words Covered	0.0756	0.0128	0.0574	0.1126
	(SE=0.1002)	(SE=0.1643)	(SE=0.1109)	(SE=0.0177)
	(p=0.5055)	(p=0.9428)	(p=0.6403)	(p=0.0079)
Democracy	0.0011	0.0009	0.0007	–0.0001
	(SE=0.0002)	(SE=0.0002)	(SE=0.0001)	(SE=0.0000)
	(p=0.0197)	(p=0.0184)	(p=0.0107)	(p=0.0017)
Education Inequality	0.0000	0.0002	0.0001	–0.0001
	(SE=0.0002)	(SE=0.0001)	(SE=0.0001)	(SE=0.0000)
	(p=0.8477)	(p=0.2144)	(p=0.5990)	(p=0.1370)
Italy Trend				0.0001
				(SE=0.0001)
				(p=0.3802)
Germany Trend				0.0001
				(SE=0.0001)
				(p=0.2646)
UK Trend				–0.0003
				(SE=0.0001)
				(p=0.0268)
USA Trend				–0.0003
				(SE=0.0000)
				(p=0.0041)
Year FE	Yes	Yes	Yes	No
r2	0.668	0.653	0.724	0.872
N	412	412	412	412

Supplementary Table 14: **Historical Determinants of the SenticNet Polarity from 1820 to 2009.** OLS with country fixed-effects estimator. SE = standard error of the mean and p = p-value.

	1 Year FE b/se/p	2 Year FE b/se/p	3 Year FE b/se/p	4 CS Trends b/se/p
(log) GDP(t-5)	0.0122		0.0089	0.0034
	(SE=0.0048)		(SE=0.0048)	(SE=0.0013)
	(p=0.0859)		(p=0.1603)	(p=0.0806)
Life Expectancy(t-1)		0.0009	0.0007	0.0002
		(SE=0.0002)	(SE=0.0003)	(SE=0.0002)
		(p=0.0144)	(p=0.0934)	(p=0.5492)
Internal Conflict(t-1)				0.0022
				(SE=0.0032)
				(p=0.5490)
Words Covered	0.1181	0.0855	0.1089	0.0927
	(SE=0.0995)	(SE=0.1090)	(SE=0.0992)	(SE=0.0105)
	(p=0.3206)	(p=0.4902)	(p=0.3526)	(p=0.0030)
Democracy	0.0007	0.0005	0.0005	–0.0000
	(SE=0.0002)	(SE=0.0001)	(SE=0.0001)	(SE=0.0000)
	(p=0.0440)	(p=0.0103)	(p=0.0198)	(p=0.4510)
Education Inequality	–0.0000	0.0000	–0.0000	–0.0000
	(SE=0.0001)	(SE=0.0001)	(SE=0.0001)	(SE=0.0000)
	(p=0.8242)	(p=0.5105)	(p=0.9332)	(p=0.1273)
Italy Trend				–0.0000
				(SE=0.0001)
				(p=0.9316)
Germany Trend				0.0001
				(SE=0.0000)
				(p=0.1943)
UK Trend				–0.0002
				(SE=0.0001)
				(p=0.0889)
USA Trend				–0.0003
				(SE=0.0000)
				(p=0.0076)
Year FE	Yes	Yes	Yes	No
r2	0.537	0.533	0.577	0.762
N	412	412	412	412

Supplementary Table 15: **Table 1 from main text with complete statistical information.** SE = standard error of the mean and p = p-value.

	1 Year FE b/se/p	2 CS trends b/se/p
National Valence Index	2.8551	1.6596
	(SE=0.2867)	(SE=0.2246)
	(p=0.0099)	(p=0.0178)
Log GDP	0.2882	0.7613
	(SE=0.0560)	(SE=0.2551)
	(p=0.0358)	(p=0.0963)
Italy Trend		–0.0125
		(SE=0.0049)
		(p=0.1236)
Germany Trend		–0.0152
		(SE=0.0045)
		(p=0.0789)
UK Trend		–0.0204
		(SE=0.0069)
		(p=0.0969)
r2	0.730	0.588
N	104	104

References

[1] Alberge, J. Publishers bypass literary agents to discover bestseller talent. Tech. Rep., *The Observer, February 22* (2015).

[2] Bernard, A. *Rotten Rejections* (Robson Books, 1990).

[3] Recchia, G. & Louwerse, M. Reproducing affective norms with lexical co-occurrence statistics: Predicting valence, arousal, and dominance. *Quarterly Journal of Experimental Psychology* **107**, 1–41 (2014).

[4] Bullinaria, J. P. & Levy, J. A. Extracting semantic representations from word co-occurrence statistics: A computational study. *Behavior Research Methods* **39**, 510–526 (2007).

[5] Davies, M. The 385+ million word corpus of contemporary American English (1990–2008+): Design, architecture, and linguistic insights. *International Journal of Corpus Linguistics* **14**, 159–190 (2009).

[6] Cambria, E., Poria, S., Bajpai, R. & Schuller, B. Senticnet 4: A semantic resource for sentiment analysis based on conceptual primitives. In *Proceedings of COLING 2016, the 26th International Conference on Computational Linguistics: Technical Papers*, 2666–2677 (2016).

[7] Veenhoven, R. World database of happiness, collection happiness in nations, overview of happiness surveys using measure type: 121A / 2-Step verbal life satisfaction. *Viewed on 2019-01-16 at worlddatabaseofhappiness.eur.nl* (2019).