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Abstract

We present a novel approach for measuring democracy based on Support Vector Machines, a mathematical algorithm for pattern recognition. The Support Vector Machines Democracy Index (SVMDI) is continuously on the 0-1-interval and enables a very detailed measurement of democracy for 188 countries between 1981 and 2011. Application of the SVMDI highlights a robust positive relationship between democracy and economic growth. We argue that the ambiguity in recent studies mainly originates from the lack of sensitivity of traditional democracy indicators. Analyzing transmission channels we conclude that democratic countries have better educated populations, higher investment shares, and lower fertility rates, but not necessarily higher levels of redistribution.

JEL-codes: C430, F500, F550, H000, O110, P480.

Keywords: democracy, economic growth, democracy index, support vector machines.

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1 Introduction

Today, the belief in democracy and its positive effects on freedom, liberty, and wealth is widespread among citizens of different countries. Covering preferences of the vast majority of the world's citizens, the World Value Survey (2014) finds that 79 percent of the global population wish to live in a country that is governed democratically.[1] This preference is not only prevalent in countries with long democratic traditions (United States: 78.7 percent, Sweden: 91.9), but can also be found in Islamic states (Pakistan: 78.3, Malaysia: 86.6), African nations (Rwanda: 74.1, Zimbabwe: 86.1), South America (Chile: 83.4, Ecuador: 84.2), and Asia (China: 80.6, South Korea: 86.0). Beginning in 2011, the unfulfilled desire for democracy in the Arab World (Egypt: 93.6, Yemen: 76.3) culminated in a wave of protests, riots, and demonstrations that spread through the nations of the Arab League and its surroundings. Driven by a fatigue with authoritarian rule, the desire for improvements of economic opportunities was one major trigger of the uprisings (see Campante and Chor, 2012).

While most of the citizens around the world seem to be quite confident that democracy brings with it an improvement in living standard, academics in political science and economics could not disagree more about the effect of democratization on economic growth. Gerring et al. (2005) summarize the academic literature by concluding that *"the net effect of democracy on growth over the last five decades is negative or null"*. More recently, some studies point to a positive effect of democracy on the income level (e.g. Acemoglu et al., 2014 and Madsen et al., 2015), whereas other surveys still find no positive contribution (e.g. Murtin and Wacziarg, 2014).

In this paper, we provide evidence of a robust positive influence of democracy on economic growth. We argue that the ambiguity in the recent literature can first and foremost be traced back to the composition of existing democracy indicators. Available indices are subject to substantial weaknesses in conceptualization, particularly with regard to the strategy employed to aggregate the underlying secondary data. As a result, existing indicators do not react with

[1] See question V140 of the World Value Survey's 6th Wave, conducted between 2010 and 2014: *"How important is it for you to live in a country that is governed democratically? On this scale where 1 means it is not at all important and 10 means absolutely important what position would you choose?"* The above number refers to all respondents that respond to the question with a value of 7 or larger.

sufficient sensitivity to political events and regime changes.

This problem is amplified by the specification of the applied estimation techniques. A large number of recent studies eliminate unobserved heterogeneity via Within-Group estimations or difference GMM. However, whereas the first method yields a considerable dynamic panel bias (Nickell, 1981), the latter is accompanied by dramatic efficiency losses if additional orthogonality restrictions can be exploited (see Blundell and Bond, 1998). Even more severely, when estimating empirical models using transformations that remove the information in the equation in levels, it is particularly necessary to have democracy indicators that react very sensitively to political events and regime changes. Otherwise, relying on the limited within-country information in the panel is likely to yield ambiguous results concerning the growth effect of democratization.

This paper addresses both challenges. In the first step, we introduce a novel approach to measure democracy which is based on machine learning algorithms for pattern recognition. These algorithms operate on the basis of a model drawn from example inputs to make data-driven predictions or decisions. The particular advantage gained via application of such methods is that they give computers the ability to learn without being explicitly programmed. Whereas the machine learning toolbox provides numerous promising instruments, Support Vector Machines (SVM) in particular have recently yielded striking results in various branches of science. Practical applications include categorization of cancer cells (Guyon et al., 2002), classification of hyperspectral data in geophysics (Gualtieri, 2009) and identification of biomarkers of neurological and psychiatric disease (Orrù et al., 2012). We transfer the SVM approach to the problem of democracy measurement, obtaining an index which we refer to as the *Support Vector Machines Democracy Indicator* (SVMDI). The indicator is continuous on the interval from 0 to 1, thereby considerably enhancing the level of detail. The most important improvement, however, is that the aggregation of the characterizing variables is not arbitrary, as our SVM algorithm puts the problem of learning—i.e. the classification of country-years—into the context of an optimization problem. The SVMDI is available for 188 countries in the period from 1981 to 2011, covering countries representative of over 99 percent of the global population.

In the second step, we analyze the effect of the SVMDI on economic growth in a system GMM framework which considers the econometric challenges described above. Our findings indicate a robust positive relationship between the SVMDI measure and economic growth. This result remains stable when changing the estimation technique to some of the recently applied strategies found in the literature. In particular, accounting for waves of democratization via instrumental variable regressions using regional and cultural democratization trends as external instruments strongly supports the baseline outcomes.

We also provide an extensive comparative analysis of the results obtained by SVMDI and alternative democracy indicators. Due to the disability of hitherto existing democracy indicators to react with sufficient sensitivity to political developments, the SVMDI is the only indicators that suggests a positive effect on growth in models that rely on the within variation of countries. This implies that even small steps in the transition process towards democracy are important to increases in living standards. However, when using the system GMM framework of our baseline estimations, the positive association between democracy and growth emerges as a clear empirical pattern, even relying on rough measures of democratization.

Finally, we investigate the transmission channels through which democracy triggers income increases. We observe that democracy exerts its influence via better education, higher investment shares, and lower fertility rates. In contrast, we find no evidence for a redistribution-enhancing effect, which may explain why we do not detect nonlinear effects of democracy in comprehensive model specifications.

The paper proceeds as follows. Section 2 discusses the ambiguity in the effect of democracy on growth in recent studies. Section 3 critically analyzes the most commonly used traditional democracy indicators. In Section 4, we introduce the ideas behind machine learning and the SVMDI algorithm. This Section further provides an overview of the democracy level and its historical trends in the world and compares the SVMDI to alternative indicators. Section 5 is concerned with the estimation strategy and the presentation of the empirical results. In Section 6, we investigate the transmission channels of democracy. We conclude in Section 7.

2 The ambiguous effect of democracy in recent studies

The effect of democracy on growth is strongly ambiguous in recent studies, both theoretically and empirically. On the theoretical side, it has been argued that democratization may benefit growth, most importantly via better provision of public goods and education (Saint-Paul and Verdier, 1993, Benabou, 1996, and Lizzeri and Persico, 2004) or by constraining kleptocratic dictators and preventing political groups from monopolizing lucrative economic opportunities (Acemoglu et al., 2008 and Acemoglu and Robinson, 2012). In addition, Alesina et al. (1996) emphasize that increased political stability enhances national and foreign investment. Feng (1997) illustrates that democracy reduces the probability of regime changes, which indirectly benefits growth. However, a large body of literature emphasizes the possible negative effects of democratization, mainly as a result of a higher level of redistribution, which is assumed to reduce growth (see, for instance, Alesina and Rodrik, 1994 and Persson and Tabellini, 1994). In addition, Olson (1982) argues that sufficient organization of interest groups can lead to stagnation in democracies.

Empirically, cross-sectional analyses conducted by Barro (1996) and Tavares and Wacziarg (2001) suggest a (slightly) negative effect of democracy on growth. The investigation of Barro (1996) also provides evidence for a nonlinear relationship between the variables, where an increase in political rights at low levels of democratization benefits growth, but triggers a negative effect if a critical threshold of democratization is exceeded. Barro (2003) confirms the nonlinear effect using panel data, where other panel data analyses yield quite ambiguous results. Rodrik and Wacziarg (2005) find no significant effect of democratic transition on growth in the long-run, but emphasize short-run benefits and a decline in economic volatility. Likewise, Apolte (2011) reports ambiguous effects of democracy on prosperity in transition countries, tentatively arguing that basic constitutional rights and constraints on the government may be conducive to growth. Burkhart and Lewis-Beck (1994), Giavazzi and Tabellini (2005) and Murtin and Wacziarg (2014) also find no robust indication of a positive relationship running from democracy to growth. Using semi-parametric methods, Persson and Tabellini (2008) report an average negative effect of departure from democracy on growth. Persson and Tabellini (2009) analyze the effect of democratic capital, measured by a nation's historical experience with democracy and by the incidence of democracy in its neighborhood. Whereas the results imply that democratic capital stimulates growth, Acemoglu et al. (2014) argue that the formidable challenge in this case is the difficulty of disentangling the impact of unobserved heterogeneity from the effect of democratic capital. Gerring et al. (2005) apply a similar approach, concluding that democratization facilitates income increases. Providing a dichotomous index of democracy, Acemoglu et al. (2014) find that the degree of democracy is positively correlated with future GDP per capita. The authors also use regional waves of democratization in an IV approach to account for possible problems caused by endogeneity. A similar approach is conducted by Madsen et al. (2015) who use the strength of democracy in linguistically comparable countries as an external instrument. Both approaches find a positive link between democracy and the level of incomes.

A different branch of literature is concerned with the reverse effect, i.e. the causal relationship of economic growth to democracy. This literature goes back to Lipset (1959), who finds a strong and positive correlation between the level of income per capita and the likelihood of transition to democracy. Recent surveys, however, provide ambiguous results. While Acemoglu et al. (2008, 2009) suggest that growth does not contribute to the process of democratization, Murtin and Wacziarg (2014) endorse Lipset's modernisation theory.

3 Recent democracy indicators

The traditional way to create a democracy indicator follows three steps: First, it is required to choose a definition of democracy. Second, a number of instruments need to be designed that are able to describe the properties of the theoretical concept. Finally, it is necessary to find a suitable manner for combining the selected variables to compute the democracy index.

In practical applications, however, a large number of problems arise in each of these steps. The first issue concerns the nature of democracy. With no generally accepted definition at hand, the interpretations range from minimal approaches primarily focusing on the election process (see, e.g., Dahl, 1971) to concepts that additionally incorporates human rights and social inequality (see, e.g., Rawls, 1971). As a result of this variety, the indicators deviate considerably in their underlying instruments. For instance, the popular index of Vanhanen (2000) only utilizes two dimensions—participation and competitiveness in elections—to characterize a democracy. The advantage of such a minimal concept is that data can be collected for a large number of countries and years, yielding a democracy indicator that covers a broad sample of observations. However, researchers employing democracy data need to acknowledge the cost-benefit trade-off and must ensure that any substantial analytical conclusion drawn in their investigation is consistent with the underlying data concept. In case of the Vanhanen-index, the allure of large data coverage comes at a high cost. First, instrumentation of participation and competition via (respectively) voter turnout and the percentage of votes going to the largest party constitute, at best, poor measures of the corresponding attribute (for a detailed discussion, see Munck and Verkuilen, 2002). Second, the aggregate index is obtained by simply multiplying the two attributes, where Vanhanen (2000) does not offer any theoretical justification for the arbitrary assumption that equal weight ought to be assigned to the attributes.

A similar minimal concept is used in the index of Boix et al. (2013) that defines a country-year as *democratic* if it meets three conditions in terms of contestation and participation.[2] The obvious drawback of this approach, one inherent to each dichotomous indicator of democracy $d_{\{0,1\}}$, is the lack of detail. In particular, the implicit assumption in empirical cross-country analyses is that each country with $d_{\{0,1\}} = 1$ is equally weighted in the computation of estimates. With regard to the Boix et al. (2013) measure for the year 2010, this implies classifying Pakistan, Bangladesh, Mali, Liberia, Sierra Leone, Zambia, and Lesotho as having the same extent of democratization as the United States, Germany, Canada, and the United Kingdom. In addition, the data sources underlying the classification of countries change over time (see Boix et al., 2013), yielding inconsistency in the indicator across periods.

Two measures of democracy have achieved a particularly high degree of popularity. These are the Polity IV score provided by Marshall et al. (2014) and the rating compiled by Freedom House (2014). What is common to both approaches is that they are neither dichotomous, nor continuous.[3] For Polity IV and Freedom House the range of possible values runs from −10 to 10 and

[2]These conditions are: (1) The executive is elected in popular elections and is responsible to voters, (2) the legislature or the executive are elected in free and fair elections, and (3) the majority of adult men have the right to vote.

[3]As Cheibub et al. (2010) emphasizes, due to the discrepancies in their components, both Freedom House and Polity IV cannot be interpreted as cardinal measures or ordinal rankings. In fact, the measures are categorial, whereby the categories are not precise.

from 1 to 7, respectively. Although they differ in their purpose, both indices are quite similar in construction, building on the evaluation of country experts who classify nations along a set of predefined criteria. In both cases, however, the aggregation strategy is fraught with problems. The Freedom House (2014) index aggregates scores for two attributes—political rights and civil liberty—by simply adding up the values of its respective underlying components. With regard to each of the two attributes, there is a bewilderingly long list of components that are all added with equal weight without any theoretical justification of this aggregation strategy. In contrast, with regard to the content of the underlying components, equal weighting seems particularly inadequate in this case.[4] The disregard of a reasonable aggregation rule is compounded by a number of conceptual and measurement problems that are discussed in detail in Munck and Verkuilen (2002) and Cheibub et al. (2010). Arbitrariness of the aggregation rule is also a fundamental deficiency of the Policy IV score (for a detailed discussion, see Treier and Jackman, 2008).

More recently, some scholars have attempted to achieve more reliable measures by synthesizing existing democracy indicators. For instance, Acemoglu et al. (2014) propose an approach that includes four established indices to obtain a dichotomous indicator. According to the applied heuristic, a country-year is classified as *democratic* ($d_{\{0,1\}} = 1$) if the rating of Freedom House (2014) is *free* or *partly free* and the Polity IV score provided by Marshall et al. (2014) is greater than zero. To address the issue that for certain observations only one of the underlying indicators is available, Acemoglu et al. (2014) use two additional indices (Boix et al., 2013 and Cheibub et al., 2010) to classify the country-years in question.[5] As in the case of the Boix et al. (2013) measure, the main drawback of this method is that it enables only a binary classification of democracy, which does not allow for a nuanced distinction between different countries. For instance, when referring to the observation in 2012, the measure of Acemoglu et al. (2014) implies that the young and fragile Tunisian democracy has the same quality as the established democracies of Canada and the United States. Employing this measure in cross-country analyses would imply

[4] For instance, it is likely erroneous to consider the decentralization of power to be as important for democracy as the actual power exercised by elected representatives (Munck and Verkuilen, 2002).

[5] As the Polity IV index only evaluates countries with at least 500,000 inhabitants, such conflicts particularly arise when considering mini-states. In addition, the data of Freedom House (2014) only reaches back to 1973, while the measure of Acemoglu et al. (2014) includes the period between 1960 and 2010.

assigning Tunisia and Canada the same value, which impedes sound interpretation of statistical estimations intended to evaluate the effect of democracy. Furthermore, a dichotomous indicator contradicts the broad consensus that cultivation of a democracy is a process which occurs over a longer period of time. Treating each country-year as equally (non)democratic neglects information on the process of democratization and results in a severe upwards bias in empirical estimations (Doucouliagos and Ulubaşoğlu, 2008).

Pemstein et al. (2010) propose another, more technical method to combine established indices. The basic idea underlying this concept is to synthesize ten available democracy indicators via a Bayesian latent variable approach to obtain the *Unified Democracy Score* (UDS). A formidable challenge presented by the inclusion of such a large number of indicators is that of dealing with the fact that the indicators differ substantially in the number of evaluated countries and periods. For instance, the Polity IV score is available continuously for the time-period from 1945 to present, while other indices are available only for very few periods. Nevertheless, the approach of Pemstein et al. (2010) includes all available information for each country-year, whereby the number of included secondary indicators varies from observation to observation. This, however, yields severe inconsistency in the UDS over time.[6] In fact, a large number of the included national series are quite constant over time, only to be interrupted by a peak occurring almost every five years when analyzing the time period between 1950 and 1980. This peak is due to the index of Bollen (2001), which is only included in the UDS in the years 1950, 1955, 1960, 1965, and 1980.[7] A very similar bias that affects the UDS of a considerable number of countries occurs in the early 1970s, the time period when the Freedom House (2014) ratings were initially published. Finally, Gugiu and Centellas (2013) emphasize that the UDS can hardly discern between countries that are not on opposite ends of the democracy spectrum, as the reported confidence intervals overlap.

The drawbacks discussed above may stand exemplarily for the majority of the existing democracy indicators. There is an extensive literature discussing the advantages and disadvantages of the democracy indicators at hand (e.g.

[6] Although for some country years the UDS was produced by drawing on information from ten democracy indicators, the majority of observations rely on an average of six underlying indicators which deviate in their composition for different country-year. This restricts comparison of UDS scores across countries and over time.

[7] See the online appendix of the paper for a graphical illustration of this effect.

Cheibub et al., 2010, Gugiu and Centellas, 2013, Munck and Verkuilen, 2002), in which the consensus has been reached that existing indices suffer from a plurality of conceptualization issues. Points of criticism include the low level of detail, the utilization of unfounded scaling, the disproportionate influence of expert knowledge, subjectivity and arbitrariness in the conceptualization, the selection of the instruments, and the theoretical concept of democracy. Above all, however, the main concern is the fairly low level of sophistication with regard to the aggregation process and the way in which the underlying components are weighted.

4 Measuring democracy using Support Vector Machines

4.1 Machine learning and Support Vector Machines

The field of machine learning studies algorithms that operate on the basis of a model drawn from example inputs that is then used to make data-driven predictions or decisions (see, e.g., Bishop, 2006). The enormous advantage gained through application of such methods is that of providing computers with the ability to learn without being explicitly programmed (Samuels, 1959). Largely developed at AT&T Bell Laboratories, the Support Vector Machines (SVM) algorithm as a subfield of machine learning was designed to have a firm orientation towards real-work applications. Hence, application of SVM has achieved very promising results in various branches of sciences. Practical applications include categorization of cancer cells (Guyon et al., 2002), classification of hyperspectral data in geophysics (Gualtieri, 2009) and identification of biomarkers of neurological and psychiatric disease (Orrù et al., 2012). In addition, the algorithm was used to categorize texts (Joachims, 2002) and to analyze hand written characters (Cortes and Vapnik, 1995).[8]

Research on SVM was heavily influenced by introduction of the Generalized Portrait algorithm in the mid-1960s (see Vapnik and Lerner, 1963 and Vapnik and Chervonenkis, 1964); however, probably the most influential milestone was

[8]Only little effort has thus far been made to apply the SVM algorithm in the field of economics, where up until now its applications has been restricted to financial topics and stock markets. For instance, Kim (2003) and Tay and Cao (2001) use SVMs for financial time-series forecasting and Shin et al. (2005) apply the method in a bankruptcy prediction model.

putting the problem of "learning" into the context of an optimization problem, thereby enabling access to the large body of already available knowledge on mathematical optimization.

The problem to be solved by the SVMs classification tool can be described as follows: Given a certain data set $\mathcal{F} = \{(X_1, y_1); ...; (X_n, y_n)\}$, where $X_i \in \mathbb{R}^m$ and $y_i \in \{-1, +1\}$, we want to find a function $\Psi \colon \mathbb{R}^m \to \mathbb{R}$ with the property

$$\Psi(X_i) = y_i \quad \forall\, i = 1, ..., n. \tag{1}$$

The general idea of the SVM algorithm is to find a hyperplane that separates the observations according to their labels y_i. However, while the optimal hyperplane algorithm introduced by Vapnik and Lerner (1963) was designed for the linear case, it is often not sufficient for computation of $\Psi(X_i)$ to rely on the initial space of the vectors X_i. For this reason, Boser et al. (1992) suggest using a higher dimensional space $\mathcal{H}$ instead—called *feature space*—where shifting of the data is accomplished by a nonlinear map $\Phi(\cdot) : X \to \mathcal{H}$, which is chosen a priori.

This procedure, however, gives rise to the question of how to treat the high-dimensional space, since an appropriate map $\Phi(\cdot)$ is typically unknown. In addition, this approach can easily become computationally infeasible with respect to polynomial features of higher order or higher dimensionalilty. To overcome this problem, Boser et al. (1992) propose a method that has become known as *the kernel trick*, largely building on the idea initially introduced by Aizerman et al. (1964). This approach circumvents direct construction of the hyperplane based on the data in $\mathcal{H}$ and relies on the dot products of the support vectors (Vapnik, 1998). This method is feasible if there exists an admissible SV *kernel function* $k(X, X_i)$ that satisfies a certain number of conditions.[9] In our application, we use the Gaussian radial basis function as a kernel, which results in the corresponding feature space $\mathcal{H}$ becoming a Hilbert space of infinite dimension.

In doing so, the optimal classification function can be calculated by

$$\Psi(X, \alpha) = \text{sign}\left(\sum_{i \in \mathcal{S}} y_i\, \alpha_i\, k(X, X_i) + b\right), \tag{2}$$

[9]See, in particular, the Theorem of Mercer (1909) and the Theorems of Schoenberg (1942) and Burges (1999).

where b is the intercept of the dividing hyperplane, $\mathcal{S}$ the set of support vectors, and α_i is computed by solving the optimization problem (Smola and Schölkopf, 2004)

$$\max_{\alpha} \sum_{i=1}^{n} \alpha_i - \frac{1}{2} \sum_{i,j=1}^{n} \alpha_i \, \alpha_j \, y_i \, y_j \, k(X_i, X_j)$$

$$\text{s.t.} \quad \sum_{i=1}^{n} \alpha_i \, y_i = 0 \quad \text{and} \quad \alpha_i \in [0, C].$$

Sample data for which it holds that the Lagrange multipliers α are nonzero—i.e. $\alpha_i \neq 0$—are called *Support Vectors*. As these observations influence the shape of the dividing hyperplane, the algorithm takes its name from this subset of data.

4.2 The SVMDI algorithm

The low degree of sophistication with respect to the aggregation of the underlying attributes is undoubtedly the main methodological weak-point of existing democracy indicators. By utilizing Support Vector Machines, we transfer the problem of aggregation into an optimization context, thereby circumventing arbitrary assumptions regarding the aggregation rule. Our numerical algorithm consists of six stages and yields a continuous measurement of democracy, which we refer to as the *Support Vector Machines Democracy Indicator* (SVMDI). Intuitively, our approach picks up the idea of Acemoglu et al. (2014) and conducts a rough binary classification based on an established democracy indicator to obtain the desired set of observations on which the SV algorithm is built. However, we only label a small selection of country-years that can be unambiguously classified as (non)democratic. The large part consisting of the remaining observations is classified by the Support Vector algorithm, which recognizes patterns in the initially labeled observations based on a number of recent democracy indicators consolidated in X_i.

To give a more detailed description of our algorithm, the first step consists of the selection of eight established variables that characterize the different aspects of a democratic state. We carefully select these determinants in order to cover a broad definition of democracy without the threat of redundancy, the latter being a point of criticism often brought forward with regard to the Polity IV index (Munck and Verkuilen, 2002). Our definition of democracy is based on a "liberal" concept of democracy in the sense of Rawls (1971) which not only builds on the election process, but also takes into account other facets of liberty and equality, such as human rights and independence of justice. Thus, the secondary data includes the ratings of civil liberty, political rights, and freedom of the press as published by Freedom House (2014), the rates of electoral participation and competition similar to those used by Vanhanen (2000) and the PTS scale of political terror (Gibney et al., 2013).[10] In addition, we incorporate two series built on data that we obtain from the CIRI dataset provided by Cingranelli et al. (2014). The first is an index reflecting independence of the judiciary (denoted by INJUD in the CIRI dataset), the second is the mean value of the five human rights scores provided by the CIRI dataset. These scores include freedom of assembly and association, freedom of religion, and freedom of speech and press as well as freedom of domestic and foreign movement.

In the second step, we select a set of country-years $\mathcal{L} \subset \mathcal{F}$ that can unambiguously be categorized as *democratic* ($d_{\{0,1\}} = 1$) and *autocratic* ($d_{\{0,1\}} = 0$), respectively. This selection lays the foundation for the SV algorithm. For the categorization of the labeled observations we follow Acemoglu et al. (2014) by using the Polity IV score as label criterion. A country-year is labeled as *democratic* ($d_{\{0,1\}} = 1$) only if the Polity IV index assumes its highest possible value of 10. At the end of the spectrum, we classify countries as *autocratic* ($d_{\{0,1\}} = 0$) if the Polity IV indicator is -7 or below. However, it is not guaranteed *a priori* that our rough criteria for labeling are valid with regard to our input variables. To test validity of the selection, we pick out $\psi_{\text{ran}} = 200$ elements of $\mathcal{L}$ with the help of a random generator and use these observations to obtain a nonlinear classification function $\Psi(\cdot)$ in accordance with the SV classification tool introduced in Section 4.1. We use $\Psi(\cdot)$ to classify all elements of $\mathcal{L}$ and compare the initial label with the value predicted by $\Psi(\cdot)$. In order to eliminate the possibility of a sample selection bias, we repeat this

[10] To circumvent some of the drawbacks inherent in the Vanhanen (2000) measurement, we adjust the data with the help of further secondary data sets. These databases include World Bank (2014a), Vanhanen (2014), Carr (2014), IPU (2014), IDEA (2014), and African Election Database (2014). We also forgo utilization of the cut-off point regarding the competition component, which is arbitrarily set to 70 percent by the index of Vanhanen (2000). In addition, we refrain from modeling the participation rate in a particular year as the number of votes cast in the last election in relation to the population size in that election year. Instead, the number of inhabitants during the respective monitoring year is used for construction of the ratio, thereby sanctioning countries in which elections only occur very intermittently.

procedure 100 times.

As an additional robustness test, we evaluate the sensitivity of our results by utilizing different values of ψ_{ran} as well as different kernels.[11] As the labels are compatible with respect to each robustness check, we are convinced that our selected criteria for labeling are valid.[12]

In the third step, a random generator selects $t_{d_{\{0,1\}}=1} = 50$ and $t_{d_{\{0,1\}}=0} = 50$ elements of $\mathcal{L}$ and consolidates them into the set $\mathcal{T}$. The algorithm proceeds (step 4) by conducting a Support Vector regression based on the observations in $\mathcal{T}$, yielding a nonlinear function $G_{\mathcal{T}}(\cdot)$.[13] For computation of $G_{\mathcal{T}}(\cdot)$, we use the Gaussian Radial Basis Function (RBF) kernel, which has provided the most promising results in our robustness check.[14] In the fifth step, we use $G_{\mathcal{T}}(\cdot)$ to classify all country-years included in $\mathcal{F}$. Finally, we compute $\zeta = 2,000$ iterations of the process from step 3 to 5. The *Support Vector Machines Democracy Index* (SVMDI) is thus the average value over the 2,000 iterations for each country-year, yielding a continuous measurement of democracy that ranges from 0 to 1.

Due to availability of the underlying data, the SVMDI is computable for 188 countries in the period from 1981 to 2011. To account for a potential bias due to inexact quantification and omitted variables, we compute confidence intervals for our SVMDI point estimates. The lower (upper) bound of these intervals corresponds with the 5th (95th) percentile of the simulated distribution of the point estimate that is computed based on the 2,000 iterations for each country-year. The SVMDI scores and the associated confidence intervals can be accessed in the online appendix of this article.

[11] While we prefer the Gaussian RBF kernel that is often used in machine learning, we also apply different Polynomial kernels with degrees ≤ 4.

[12] To evaluate if our consistency check is able to detect inappropriate criteria, we also mislabeled a number of observations. For instance, we assigned all observations of China—which were originally labeled as *autocratic*—a democratic label. As the series on which the classification is built implies labeling all Chinese country-years as autocratic, the SVM classification tool strongly rejects our (wrong) choice. As a result, we can conclude that the applied consistency test is able to detect misclassification if the share of misspecifications is in the minority.

[13] We provide a brief overview of the application of Support Vectors as a regression tool in the online appendix. For a more detailed description see Smola and Schölkopf (2004).

[14] In addition, Gaussian RBF is most commonly applied in the field of machine learning.

4.3 Democracy in the world

We now turn to a detailed illustration of the democratic tendencies in the world implied by our indicator. Figure (1) maps the SVMDI data in the post-2010 period. This yields a very heterogeneous picture: while countries in Europe, Oceania, North America, and—to a large extent—in South America possess high SVMDI scores, a substantial part of the nations in Africa and Asia are considerably less democratic.

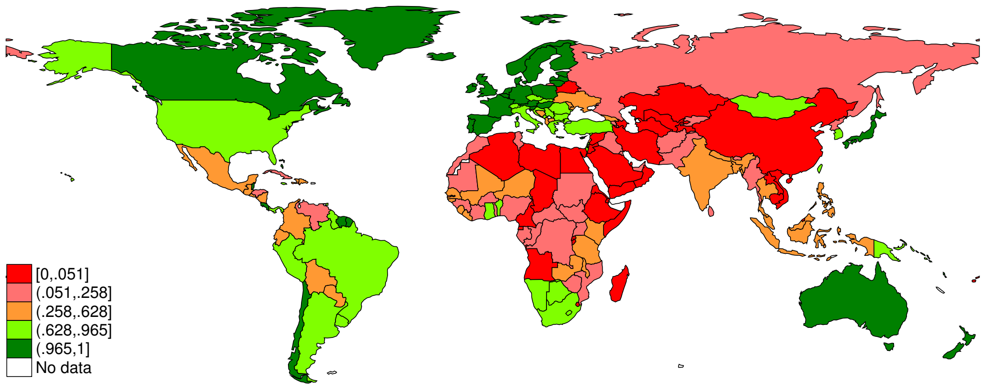

Figure 1 Democracy in the world (SVMDI), post-2010 period. Classes refer to the quintiles of the distribution of the SVMDI indicator.

An interesting pattern revealed by Figure (1) is that the degree of democratization shows clear tendencies towards regional concentration. If a country is (non-)democratic, we observe a high probability that the same applies to its neighboring country. There are three remarkable exceptions to that general rule: landlocked by countries with very low SVMDI scores, Mongolia (SVMDI: 0.8068), Ghana (0.9302), and—to a lesser extent—Benin (0.6413) succeeded in establishing democratic structures. Overall, the figure suggests a strong polarization of the extent of democratization.

This polarization becomes particularly apparent when we consider the distribution of the SVMDI measure, which is illustrated in Figure (2). The data suggests a bimodal distribution, where the first mode is located at a very low level of democracy, and the second mode lies at a substantially higher degree of democracy. This pattern is typical when examining the degree of democracy across countries and occurs in a similar manner when analyzing alternate measures. The reason is that there exist a substantial number of countries with an SVMDI index close to zero. These countries include nations where civil wars are prevalent—e.g. Syria (0.0337), Afghanistan (0.0934), and Sudan

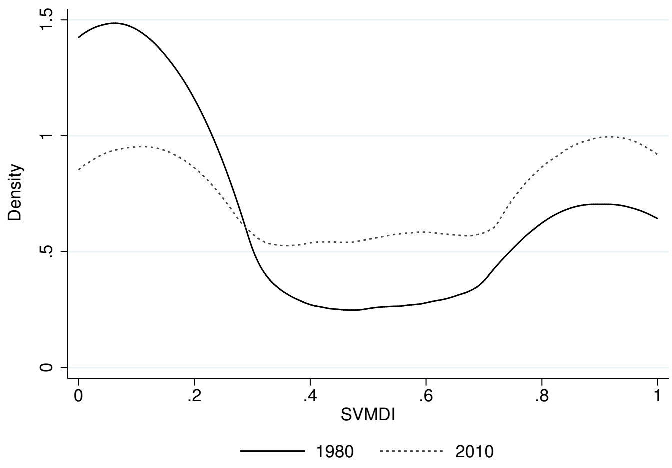

Figure 2 Democracy in the World, SVMDI data, kernel density estimates 1980—2010. Kernel is Epanechnikov.

(0.0601)—and countries with absolute monarchies, such as Swaziland (0.0069), Qatar (0.0305), and Brunei (0.0259). On the other hand, there are numerous countries where strong democratic institutions have been established, particularly in Europe, North America, Oceania and in some parts of Latin America. Figure (2) also demonstrates that democratization emerges as a clear empirical pattern in the SVMDI data. Whereas the relative fraction of non-democratic nations was extraordinarily high in the 1980-1984 period, the data approximates a more uniform distribution in the post-2010 period, where we observe a substantially higher number of democratic countries and a lower number of nations with a poor SVMDI score.

Figure (3) exemplarily plots the SVMDI scores and the confidence intervals for Serbia, South Korea, Venezuela, and Argentina over the entire period between 1981 and 2011.[15] The figure highlights the considerable progress in democratization during the 1980s and the early 1990s, which has later become known as "Democracy's Third Wave" (see, for instance, Huntington, 1991, 2012). Beginning in Latin America in the early 1980s, the Third Wave washed over to Asia Pacific countries and reached its crest in Eastern Europe after the collapse of the Soviet Union. This development is clearly visible in the SVMDI data. Particularly noteworthy is the substantial progress achieved in South Korea and Argentina, both of which were classified as highly autocratic

[15]Note that the Serbian SVMDI is composed of the scores of SFR Yugoslavia (1981-91), FR Yugoslavia (92-02), Serbia and Montenegro (03-05), and Serbia (06-11).

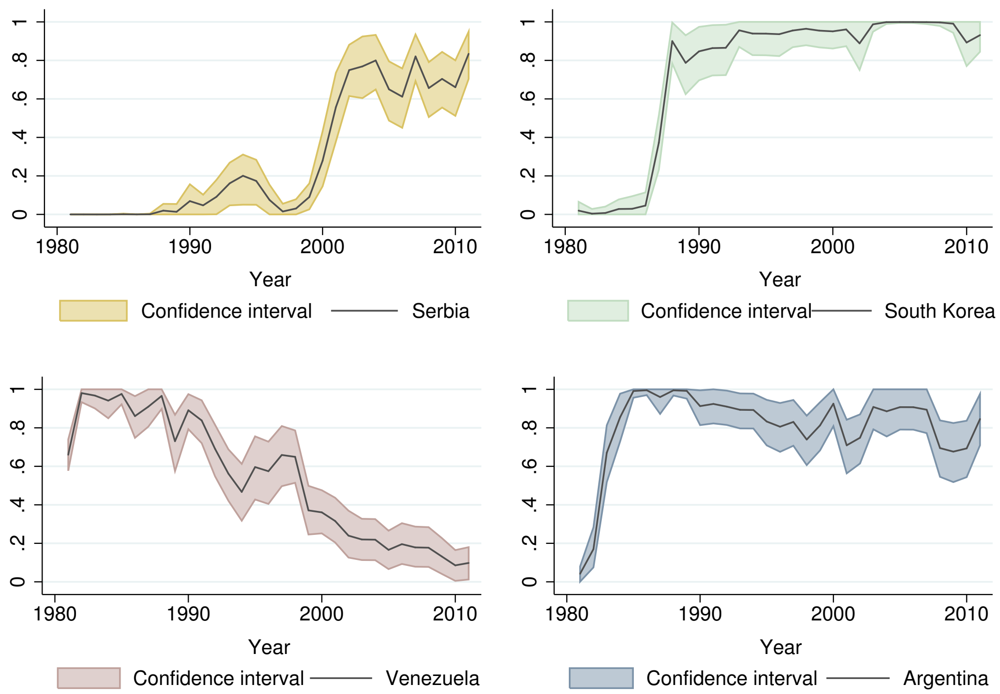

Figure 3 The path of democratization. SVMDI scores and confidence intervals of Serbia, South Korea, Venezuela and Argentina, whole period (1981-2011).

in the early 1980s. Similar movements towards democracy can be observed in Eastern Europe after the fall of the Iron Curtain in 1989. The Serbian path to democracy, however, was more tortuous than those of its Baltic and East-Central European neighbors. Only following the resolution of the armed conflicts in Bosnia and Herzegovina (1992-1995) and Kosovo (1998-99) was an increase in political rights and democratization initiated (see McFaul, 2002). Yet democracy has not yet been cultivated in full, which is exactly reflected in the SVMDI of the country (Greenberg, 2014).

A further issue that has gained increasing attention is the fear of a potential "reverse" wave occurring in Latin America due to the importance of autocracy and military in the region's political culture, as well as the strong institutional position of its armed forces. Such a movement has already been ushered in Venezuela and Paraguay (see Zagorski, 2003). As Venezuela was part of the Third Wave in the early 1980s, the SVMDI implies that it succeeded in establishing democratic structures at that time. However, the relapse was not long in coming. The data suggest a clear tendency towards autocracy, which was initiated in the early 1990s and constantly promoted during the presidency of

Hugo Chávez (Levitsky and Murillo, 2008).
Similar tendencies emerged in Argentina during the presidency of Carlos Menem (1989-1999). While Argentina's democracy in the mid 1980s was more stable than previous regimes, it failed to establish enduring democratic institutions (Levitsky and Murillo, 2008). In fact, President Menem increasingly limited both the power of the congress and the independence of the Supreme Court (Larkins, 1998), resulting in Argentina's movement towards a *delegetive democracy* shaped by weak control mechanisms between different state agencies (O'Donell, 1994). With the presidential dominance and the centralization of power still holding on (Elias, 2015, Levitsky and Murillo, 2008), Argentina's political and economic institutions remain strikingly weak under the presidency of Néstor Kirchner (2003-2007) and his wife Christina Fernández de Kirchner (2007-present).

4.4 Relation to existing democracy indicators

One huge advantage of the SVMDI algorithm is that aggregation of the underlying attributes is much less arbitrary, as it relies on much weaker assumptions. In particular, unification of attributes is conducted via a nonlinear optimization problem rather than via crude aggregation rules or the implicit assumption of equal weights. In addition, combining information from existing democracy indicators compensates for weaknesses in conceptualization as well as for measurement errors in the underlying secondary data. A direct result of these methodical improvements is a substantial increase in the level of detail in comparison to established approaches.
To demonstrate the superiority of the SVMDI algorithm, Figure (4) plots the democracy levels of Jamaica, Nicaragua, Venezuela, and Mongolia as gauged by SVMDI and several other indicators. Note that we have normalized all indices to values between 0 and 1 in order to ensure sufficient comparability of the measurements.[16]
First, consider the case of Jamaica. What is striking in terms of the classification of the Jamaican democracy is the huge divergence between the trends observed in the early 1980s by the SVMDI and those identified by alternative measures. While the Polity scores and the Freedom House (2014) ratings do not

[16]It is crucial to emphasize that the superiority of the SVMDI score in describing recent political developments is not limited to the illustrated countries, but can be observed with respect to the overwhelming majority of country-years included in the data.

change notably, the SVMDI score experiences a sharp decline in the year 1983. Given the political situation in that year, the result suggested by the SVMDI algorithm is much more plausible. In 1983, the "People's National Party"—until that time the largest opposition group in the parliament—boycotted the election, which resulted in the incumbent "Jamaica Labor Party" winning all seats in the election (Figueros, 1985). In fact, whereas 54 of 60 seats were completely unopposed, voting took place in six seats due to participation of minor parties. However, nationwide voter turnout was only 2.7 percent, which was the lowest value in the history of the country and the only time that it was below 50 percent (Wüst, 2005). From that time until 1989, Jamaica was a de facto one-party state. Such a situation, however, should factor negatively into a democracy measure, as political pluralism in parliament is an important aspect of democracy, even in minimal concepts such as that proposed by Dahl (1971). Without the control and criticism provided by a parliamentary opposition, the ruling party is able to exercise power without supervision. In fact, the rule of Edward Seaga, Prime Minister of Jamaica from 1980 to 1989, became increasingly authoritarian, which led to widespread public protest during the election in 1989 (Wüst, 2005).

The case of Nicaragua highlights a typical pattern of the Vanhanen (2000) index, which in the overwhelming majority of observations only changes (slightly) after elections have taken place. In Nicaragua, elections are held every five years. While the Vanhanen-index implies an increase in democracy in each electoral year, it remains unaltered during the periods in between. In particular, with the exception of a minor decline in 2011, the index provides no indication for a decrease in the degree of democracy during the entire period. Likewise, the Polity score (Marshall et al., 2014) implies a similar period of flourishing democracy without any indication of an interruption. The dichotomous indicator of Acemoglu et al. (2014) changes only once in 1990, the year when the first competitive election in the country took place (Williams, 1990). Notwithstanding the consensus that Nicaragua's democracy is far from being in full bloom (Walker, 2009), the indicator suggests strong democratic structures in the country. In contrast, the SVMDI displays a continuous loss of democracy since 2006, the year when Daniel Ortega came into his second presidency after years as a member of the opposition. Due to the increasingly autocratic governance of President Ortega—including, for instance, growing oppression of critical journalists and opposition members, as well controversial

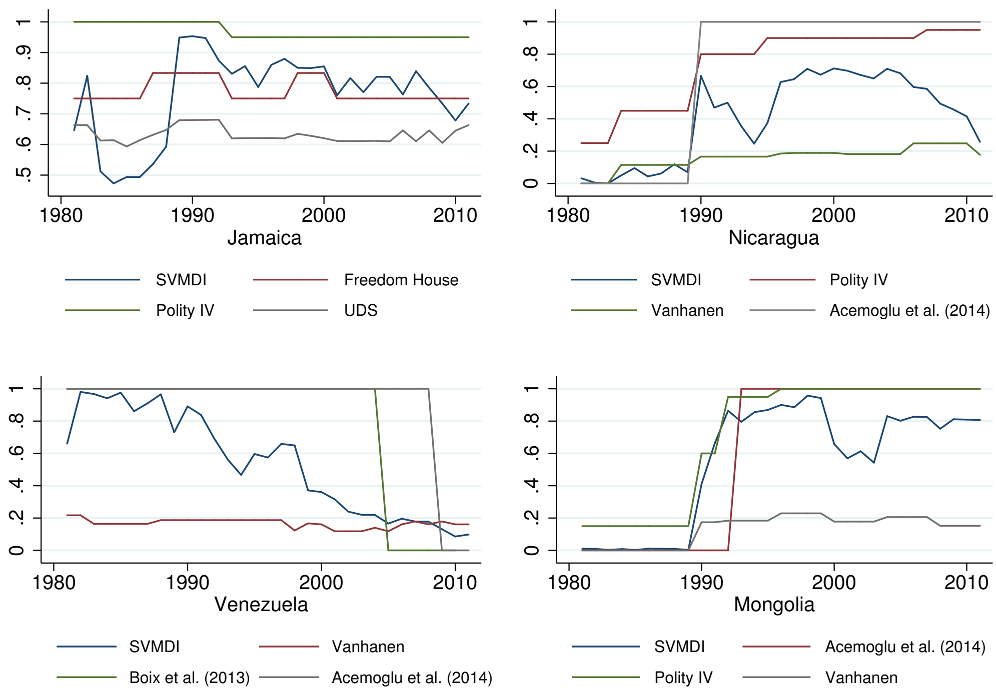

Figure 4 Democracy in Jamaica, Nicaragua, Venezuela, and Mongolia. SVMDI and traditional democracy indicators, 1980-2011.

constitutional amendments (Anderson and Dodd, 2009, McConnell, 2014)—a decreasing trend is much more justifiable than a constant or even increasing level.

The third nation illustrated in Figure (4) is Venezuela. As highlighted in Figure (3) in the previous section, democratization in Venezuela experienced a decline during the past decades. This phenomenon is intensely discussed in the literature as a "reverse wave" of democracy (see, e.g., Huntington, 2012). However, the breakdown in Venezuelan democracy is captured quite differently by traditional democracy indicators. Whereas the indices from Boix et al. (2013) and Acemoglu et al. (2014) attest to a thriving democracy until the end of the 2000s, the index of Vanhanen (2000) remains at a constant level of roughly 0.20 over the whole period between 1981 and 2011, indicating no noteworthy decline in democracy at all. The SVMDI, however, illustrates that the antidemocratic trend in Venezuela has already begun during the 1990s, which is much more in line with the existing literature (see, e.g., Zagorski, 2003 and Levitsky and Murillo, 2008).

The last country depicted in Figure (4) is Mongolia. The figure highlights that the SVMDI algorithm is able to detect differences between country-years that have originally obtained a label in step two, i.e. observations that are elements of $\mathcal{L}$. Although Mongolia received a label of 1 for the period between 1999 and 2011, the figure clearly shows that the degree of democracy has changed considerably over time.[17] What is striking about the figure is the sharp decline in the SVMDI of Mongolia in 2000. In this particular year, the ex-communist Mongolian People's Revolutionary Party (MPRP) won 72 of 76 seats, resulting in Mongolia's shift towards a one-party system (Severinghaus, 2001). Such a development, however, stands in contrast to some established definitions of democracy that typically require a multiple-party system. In fact, political competition is a central issue in theoretical and empirical concepts relating to democracy (see, for instance, Dahl, 1971, Huntington, 2012, Vanhanen, 2000). As the vote in the 2004 Mongolian parliamentary election was evenly split between the MPRP and the Motherland Democratic Coalition, Mongolia's SVMDI experienced a renewed increase. When relying on traditional indicators—such as Polity IV and the measures of Vanhanen (2000) and Acemoglu et al. (2014)—no changes in democratization are observable.

In the online appendix, we illustrate the overall relationship between the SVMDI measure and alternative democracy indicators that are most often used in recent studies.

5 The empirical effect of democracy on growth

5.1 Estimation strategy

We now turn to the empirical investigation of democracy, measured via the SVMDI algorithm, and growth. Our analysis uses a standard framework of empirical growth regressions to estimate the effect of democracy on growth, utilizing 5-year averages of all variables. Averaging the data is necessary due to the long-term perspective of growth theory, the need to disentangle short-term fluctuations and long-term effects, and the occurrence of gaps in the data concerning some of the covariates. Considering additive linkage of the

[17] In order to make these slight differences computable, we only use a subset $\mathcal{T}_\zeta \subset \mathcal{L}$ with $|\mathcal{T}_\zeta| \ll |\mathcal{L}|$ to estimate $G_{\mathcal{T},\zeta}(\cdot)$ in iteration ζ. This procedure enables detection of possible differences between country-years that have been classified with $d_{\{0,1\}} = 1$ (democratic) in the second step.

variables, our basic dynamic panel specification is[18]

$$y_{it} = \theta y_{it-1} + \lambda h_{it} + \beta \mathbf{X}_{it} + \gamma d_{it} + \eta_i + \xi_t + v_{it} \tag{3}$$

where y_{it} is the log of initial per capita GDP in i at 5-year period t, h_{it} is human capital endowment, d_{it} is the democracy index, and $\mathbf{X}_{it}$ includes the covariates of the regression. The selection of the covariates is based on the standard framework of Barro (2003, 2013), which has been proven to capture the empirical determinants of economic growth quite accurately in a number of studies. These variables include the logarithmic value of real per capita GDP in $(t-1)$ to account for conditional convergence, denoted by $\log(\text{GDP}_{pc})$; the investment share (INVS); government consumption (GOVC); the inflation rate (INFL); the degree of openness (OPEN); and the log of the fertility rate, log(FERT). Human capital enters into the equation using average years of schooling (SCHOOLY) and log(LIFEEX), the log of life expectancy at birth, to proxy education and health respectively.[19] We do not include measures of physical capital, as their calculation relies on arbitrary assumptions regarding depreciation and the initial value. Rather, we follow Barro (2003, 2013) in assuming that higher levels of $\log(\text{GDP}_{pc})$ and h_{it} reflect higher levels of capital endowment.

Equation (3) also captures country-specific effects η_i and time effects of period t, denoted by ξ_t, in order to account for the various institutional aspects of the countries. The term $v_{it} \equiv u_{it} - \xi_t - \eta_i$ denotes the idiosyncratic error of the model.

A common and widely-used approach to account for both unobserved heterogeneity and endogeneity is the estimator proposed by Arellano and Bond (1991). Define for reasons of lucidity that $\nabla k \equiv (k_{it} - k_{it-1})$ and $\nabla_2 k \equiv (k_{it-1} - k_{it-2})$, the basic idea of this approach is to adjust (3) to

$$\nabla y = \theta \nabla_2 y + \lambda \nabla h + \gamma \nabla d + \beta \nabla \mathbf{X} + \nabla \xi + \nabla v \tag{4}$$

[18]This specification is obtained by following the model structure developed in a number of recent empirical investigations where the growth rate is modeled to evolve as $y_{it} - y_{it-1} = (\theta - 1)y_{it-1} + \lambda h_{it} + \beta \mathbf{X}_{it} + \gamma d_{it} + \eta_i + \xi_t + v_{it}$ (see, e.g., Bond et al., 2001, Voitchovsky, 2005, and Halter et al., 2014).

[19]The data used in the regression stems from commonly used data sources in empirical growth research. $\log(\text{GDP}_{pc})$, INVS, GOVC, OPEN and INFL are from PWT 8.0 as documented in Feenstra et al. (2013), SCHOOLY is from Barro and Lee (2013), log(LIFEEX) and log(FERT) are from World Bank (2014b).

and then use sufficiently lagged values of y_{it}, h_{it}, d_{it}, and $\mathbf{X}_{it}$ as instruments for the first-differences. However, first differencing Equation (3) removes the information in the equation in levels. This drawback is particularly severe with regard to the purpose of this paper, as large parts of the variation in democracy data stem from the cross section rather than the time-dimension. This particularly holds for hitherto existing democracy indicators. Blundell and Bond (1998) and Bond et al. (2001) show that the standard first-difference GMM estimator can be poorly behaved if time-series are persistent or if the relative variance of the fixed effects η_i is high. The reason is that lagged levels in these cases provide only weak instruments for subsequent first-differences, resulting in a large finite sample bias. In addition, difference GMM magnifies gaps in unbalanced panels, as it requires at least three consecutive lags for each of the variables. This requirement results in an asynchronous loss of observations, because data availability is typically more limited in developing countries. However, we are particularly interested in observations concerning developing economies, as these country-years contain information regarding the growth effect of regime changes in transition economies.

System GMM proposed by Arellano and Bover (1995) and Blundell and Bond (1998) provides a tool to circumvent the previously described biases, if one is willing to assume a mild stationary restriction on the initial conditions of the underlying data generating process.[20] In this case, additional orthogonality conditions for the level equation in (3) can be exploited, using lagged values of ∇k and $\nabla_2 k$ as instruments. By these means, system GMM maintains some of the cross-sectional information in levels and exploits the information in the data more efficiently. Satisfying the Arellano and Bover (1995) conditions, system GMM has been shown to have better finite sample properties (see Blundell et al., 2000). To detect possible violations of these assumptions, we conduct Difference-in-Hansen tests for each of the system GMM regressions.[21]

Let $\mathbf{\Theta}'_{it} \equiv [y_{it}\ h_{it}\ d_{it}\ \mathbf{X}'_{it}]$, the moment conditions in our analysis used for the regression in first-differences are

$$\mathrm{E}[(v_{it} - v_{it-1})\mathbf{\Theta}_{it-s}] = 0 \text{ for } t \geq 3,\ 2 \leq s \leq 3,$$

[20]The assumption on the initial condition is $\mathrm{E}(\eta_i \nabla y_{i2}) = 0$, which holds when the process is mean stationary, i.e. $y_{i1} = \eta_i/(1-\theta) + v_i$ with $\mathrm{E}(v_i) = \mathrm{E}(v_i\eta_i) = 0$.

[21]A more detailed description of the estimator in the context of the empirical application can be found in Bond et al. (2001) and Roodman (2009b).

and the additional moment conditions for the regression in levels are given by

$$\mathrm{E}[(v_{it} + \eta_i)(\boldsymbol{\Theta}_{it-1} - \boldsymbol{\Theta}_{it-2})] = 0 \text{ for } t \geq 3.$$

We restrict the instrument matrix to lag 3. Roodman (2009a) illustrates the need to introduce such a restriction, as otherwise the problem of "instrument proliferation" may lead to severe biases. In principle, our specification can be estimated using one-step or two-step GMM. Whereas one-step GMM estimators use weight matrices independent of estimated parameters, the two-step variant weights the moment conditions by a consistent estimate of their covariance matrix. Bond et al. (2001) show that the two-step estimation is asymptotically more efficient. Yet it is well known that standard errors of two-step GMM are severely downward biased in small samples. We therefore rely on the Windmeijer (2005) finite sample corrected estimate of the variance, which yields a more accurate inference.

5.2 Baseline results

Panel A of Table 1 reports the results of the baseline regressions. The first column illustrates the effect of democracy measured by the SVMDI in a restricted model where the only covariate is the initial income level. The advantage of examining the effect of democracy in a very reduced specification is that the estimated parameter captures the full growth effect of democracy, leaving all possible transmission channels open. In addition, this estimation enables the investigation of SVMDI in a broad sample of 160 countries. The subsequent columns examine the effect of the SVMDI when additional controls are introduced; however, limited data availability for the covariates yields a decline in the number of countries included in the estimation. Panels B and C use exactly the same specifications as Panel A, but examine the influence of *initial* democracy in $(t-1)$ as well as nonlinear effects of democracy.

The result in Column (1) of Panel A provides clear indication that democracy and income increases are positively and significantly related. The column rejects the hypothesis of convergence, reflecting the well-known argument in empirical growth research that convergence can only be detected when holding constant a number of variables that distinguish the countries (see, for instance, Barro and Sala-i Martin, 1992). For this reason, the subsequent columns gradually introduce a number of standard controls in empirical growth regressions.

Table 1 The effect of SVMDI on growth, dependent variable is real per capita GDP growth.

	(1)	(2)	(3)	(4)
	Panel A: Baseline regression results			
Log(GDP$_{pc}$)	0.00479	-0.00839**	-0.0180***	-0.0197***
	(0.00492)	(0.00342)	(0.00349)	(0.00309)
SVMDI	0.0264***	0.0242***	0.0149**	0.00294
	(0.00941)	(0.00840)	(0.00750)	(0.00684)
INVS		0.120***	0.0467	0.0445
		(0.0346)	(0.0310)	(0.0323)
SCHOOLY		0.00225	0.00214*	0.000111
		(0.00199)	(0.00123)	(0.00129)
Log(LIFEEX)			0.102***	0.0635***
			(0.0222)	(0.0206)
GOVC			-0.0112	-0.0168
			(0.0304)	(0.0291)
INFL			-0.00126*	-0.00110
			(0.000651)	(0.000680)
OPEN			0.00625*	0.00268
			(0.00331)	(0.00356)
Log(FERT)				-0.0333***
				(0.00643)
	Panel B: The effect of initial democratization			
SVMDI($t-1$)	0.0223*	0.0293**	0.0193*	0.00974
	(0.0134)	(0.0123)	(0.0108)	(0.00684)
	Panel C: Non-linear effect of democracy			
SVMDI	0.121***	0.0189	0.00944	0.00512
	(0.0431)	(0.0391)	(0.0227)	(0.0199)
SVMDI SQUARED	-0.107**	0.00297	0.00428	-0.000991
	(0.0446)	(0.0421)	(0.0235)	(0.0197)
SLM p-val	0.0284	1.000	1.000	1.000
Observations	1048	857	775	775
Countries	160	129	128	128
Hansen p-val	0.0000928	0.0262	0.878	0.991
Diff-in-Hansen	0.109	0.691	1.000	1.000
AR(1) p-val	0.0416	0.0777	0.116	0.119
AR(2) p-val	0.367	0.273	0.335	0.327
Instruments	40	78	154	173

Notes: Table reports two-step system GMM estimations. All estimations use period fixed effects and Windmeijer-corrections, robust standard errors in parentheses. The instrument matrix is restricted to lag 3. Test statistics refer to Panel A. Hansen p-val. gives the p-value of Hansen's J-test, AR(1) p-val. and AR(2) p-val. report the p-values of the AR(1) and AR(2) test. Diff-in-Hansen reports the p-value of the C statistic of the difference in the p-values of the restricted and the unrestricted model. The unrestricted model ignores the Arellano and Bover (1995) conditions. $*p < .10$, $**p < .05$, $***p < .01$.

The motivation for including additional controls is twofold. First, Hansen's p-value points to an omitted variable problem in the reduced regression in Column (1), which may result in a bias in the estimated parameter. Second, we aim to investigate the mechanism through which democracy affects incomes by introducing potential transmission channels of democracy, as suggested by Tavares and Wacziarg (2001).

When introducing the investment share and the average years of schooling in Column (2), *conditional* convergence in the form of a negative relationship between initial incomes and growth can be observed. What is remarkable in this estimation is the robustness of the effect of SVMDI, which remains significantly positive and maintains its magnitude. In Column (3) we incorporate life expectancy at birth, government consumption, the inflation rate, and the openness of countries. The effect of democracy remains positive and significant, but the marginal effect shrinks slightly. The latter is in line with the findings of Doucouliagos and Ulubaşoğlu (2008), who show that inclusion of these additional covariates reduces the marginal impact of democracy on growth. Investigating bivariate correlations between SVMDI and the newly introduced covariates, our data implies that democracies tend to have higher life expectancies (correlation: 53 percent) and a lower probability of hyperinflation (-31 percent). Each of these effects stimulates growth, which is why the column suggests a lower marginal impact of SVMDI. Finally, when introducing the fertility rate, the effect of democracy becomes insignificant. As democracies tend to have substantially lower fertility rates (correlation: -60 percent), the fertility channel appears to be a crucial transmission mechanism of democracy on growth. In countries where non-democratic structures are prevalent, the trade-off between the quantity and the education of the children is often resolved in favor of having more offspring. In light of binding budget constraints, families may consider this a substitute for missing social security systems.

The test statistics given in the lower part of Table (1) highlight the high degree of validity of our results. The AR(2) p-value illustrates that there is no second-order serial correlation in the residuals. In addition, once additional controls are introduced in Columns (2)-(4), the p-value of Hansen's J-test suggests that an omitted variable bias becomes increasingly unlikely. Finally, the Difference-in-Hansen statistics highlight validity of the instrument subsets used for the level-equation, which implies superiority of system GMM over difference GMM.

Overall, there is a clear indication of a positive effect of democracy measured by SVMDI on the growth rate. This effect remains positive and significant in Panel B, which investigates the impact of the initial democratization level by inclusion of SVMDI in $(t-1)$. Whereas the marginal effect in the reduced specification in Column (1) slightly declines from 0.0264 to 0.0223, the influence of initial democracy tends to be marginally stronger than current democracy in the subsequent regressions. As in Panel A, the effect of democratization vanishes once additional controls are introduced that account for the transmission channels of democracy, particularly the fertility rate.

Some authors have stressed a non-linear relationship between democracy and growth, arguing that democracy enhances income increases at low levels of political freedom but depresses growth once a moderate level has been attained (see, e.g., Barro, 1996). In dictatorships, an increase in political rights may be growth enhancing due to the advantages arising from limitations on governmental power, increases in contractual freedom, and reductions in foreign trade barriers. At high levels of democracy, however, a further increase may eventually be an impediment to growth due to increases in redistributive efforts. Panel C deals with the examination of a possible nonlinear effect of democracy by inclusion of the squared SVMDI score. Whereas Column (1) provides indication of a parabolic influence of democracy on growth, the effect vanishes when additional covariates are incorporated. The Sasabuchi-Lind-Mehlum (SLM) test of Lind and Mehlum (2010) also indicates the presence of an inverted-U relationship in the reduced model, but does not detect a similar pattern in the more comprehensive specifications.

5.3 Sensitivity analysis I: Different estimation techniques

Subsequently, we explore whether our results are sensitive to the specified estimation strategy. Table 2 provides the results of two adjustments of Table (1). The first adjustment is first-difference GMM as proposed by Arellano and Bond (1991), and the second method uses Within-Group estimations. Both methods have been applied in recent studies concerning the effect of democracy on income increases (e.g. in Acemoglu et al., 2014, Rodrik and Wacziarg, 2005 and Gerring et al., 2005). The table reports three variants of each technique. The first specification is the reduced model of Column (1) of Table 1, while the second and third columns refer to the more comprehensive models reported in

Columns (3) and (4) of Table 1. The columns are labeled in accordance with the variant of the baseline table that is used for specification.

Overall, the effect of democratization is remarkably stable across the regressions conducted in Table 2, strongly resembling the findings of the baseline estimations in significance and magnitude. One exception is the effect of SVMDI in the reduced model reported in Column (1), where Hansen's J-test again suggests an omitted variable problem. In addition, the Difference-in-Hansen test reported in Table 1 indicates that the additional moment conditions used in the system GMM estimation are valid, suggesting substantial efficiency losses when utilizing difference GMM. Note also that the number of observations declines from 1048 to 888, as difference GMM requires observations for at least three consecutive periods. This technique draws on variations over time and eliminates the information in the equation in levels. Thus, when conducting difference GMM estimations, we expect the main effect of democracy to appear via the transition of non-democracies to democracies. Differencing the data, however, mainly yields losses of precisely the observations that we are interested in, i.e. observations from developing economies during the transition process. When introducing additional controls in Columns (3) and (4), the positive and significant effect of SVMDI found in the baseline model reappears. This is a strong indication that democracy exerts its influence via a number of transmission channels, which have opposing effects on growth. If we do not control for the effects of these variables, the estimated parameter of SVMDI captures the contrary effects of the transmission variables and becomes insignificant.

The Within-Group (WG) estimations also strongly support the results of the baseline table. This technique resembles the estimation strategy conducted by Gerring et al. (2005), Rodrik and Wacziarg (2005) and Papaioannou and Siourounis (2008). However, one concern is that introducing a lagged dependent variable in a WG model most likely results in a Nickell (1981) bias. In addition, WG does not account for possible problems caused by endogeneity, which we typically expect in growth regressions.

Table 2 The effect of SVMDI on growth, different estimation techniques. Dependent variable is real per capita GDP growth.

	First-difference GMM (Arellano-Bond)			Within-Group (WG)		
	(1)	(3)	(4)	(1)	(3)	(4)
Log(GDP$_{pc}$)	-0.139***	-0.0781***	-0.0756***	-0.0329***	-0.0589***	-0.0579***
	(0.0341)	(0.0131)	(0.0136)	(0.00636)	(0.00873)	(0.00849)
SVMDI	-0.00214	0.0325**	0.0258*	0.0279***	0.0134**	0.00881
	(0.0407)	(0.0134)	(0.0133)	(0.00584)	(0.00616)	(0.00600)
INVS		0.0816**	0.0784**		0.0808**	0.0709**
		(0.0360)	(0.0358)		(0.0325)	(0.0322)
SCHOOLY		0.00292	-0.00343		0.00813***	0.00300*
		(0.00468)	(0.00595)		(0.00170)	(0.00176)
Log(LIFEEX)		0.0218	0.00948		0.133***	0.121***
		(0.0475)	(0.0432)		(0.0245)	(0.0231)
GOVC		0.0269	0.0290		-0.00852	-0.00502
		(0.0320)	(0.0328)		(0.0213)	(0.0212)
INFL		-0.000960	-0.000678		-0.000731	-0.000721
		(0.000636)	(0.000489)		(0.000549)	(0.000543)
OPEN		0.00288	0.00346		-0.00107	-0.000940
		(0.00460)	(0.00569)		(0.00400)	(0.00387)
Log(FERT)			-0.0278			-0.0405***
			(0.0194)			(0.00866)
Observations	888	647	647	1048	775	775
Countries	160	128	128	160	128	128
Hansen p-val	0.00841	0.211	0.263			
AR(1) p-val	0.0582	0.113	0.115			
AR(2) p-val	0.0590	0.221	0.230			
Instruments	27	99	111			

Notes: Table reports first-difference GMM (Arellano-Bond) and Within-Group (WG) estimations. Robust standard errors in parentheses. WG uses cluster robust standard errors. The instrument matrix in Columns (1)-(3) is restricted to lag 3. Hansen p-val. gives the p-value of Hansen's J-test, AR(1) p-val. and AR(2) p-val. report the p-values of the AR(1) and AR(2) test. $*p < .10$, $**p < .05$, $***p < .01$.

5.4 Sensitivity analysis II: Regional and cultural waves of democratization

We now turn to another branch of sensitivity analyses, conducting IV regressions with SVMDI instrumented by regional and cultural democratization. This technique, used in some more recent studies of the topic (see, e.g., Acemoglu et al., 2014 and Madsen et al., 2015), is motivated by the empirical observation that democratization often occurs in waves. Section 4.3 demonstrates that the SVMDI measure implies a multinational trend in democratization in the world during the 1980s and the early 1990s, which Huntington (1991, 2012) refers to as "Democracy's Third Wave". In addition, the renunciation of authoritarian regimes during the Arab Spring provides more recent experience with regional entanglements in the process of democratization. Spreading from one country to another, waves of democratization may be a satisfactory determinant of exogenous variation in democracy (Persson and Tabellini, 2009). We follow Acemoglu et al. (2014) in assuming that, conditional on covariates, democratization in neighboring countries should be uncorrelated with national GDP.[22] This allows for creation of external instruments of democracy which capture the effect of democratization waves.

We use two different approaches to form our external instruments. The first approach refers to Acemoglu et al. (2014), instrumenting country-year $\{i, t\}$ with jack-knifed average SVMDI of region r (denoted by Z_{it}^r) in which i is located. In order to satisfy the exclusion restriction, we leave out the own country in the calculation of Z_{it}^r. The crucial challenge in computing Z_{it}^r is the accurate definition of the decisive regions. Whereas a narrower concept is more likely to include the countries that directly influence national demand for democracy, it poses the risk of leaving out information necessary to accurately instrument national SVMDI scores. In addition, arbitrary classification of regions may cause a distortion of the results. For this reason, Table 3 uses two different definitions of regions. The first (wide) definition refers to the country classification of the World Bank, the second (narrower) definition splits each continent into four disjoint regions, as illustrated in appendix A2.

The second approach weights the SVMDI of the countries by their cultural distance from i. We refer to this instrument as $\tilde{Z}_{it}^r$. While this procedure

[22] Whereas we could imagine plausible reasons why this assumption may be violated—e.g. due to a decline in regional trade or capital flows—Acemoglu et al. (2014) provide evidence that controlling for such effects has little effect on the estimation results.

builds on the method proposed by Madsen et al. (2015), we use the cultural dimensions from Hofstede (2001) to capture cultural diversities rather than linguistic differences. The advantage of $\tilde{Z}_{it}^{r}$ is that the exclusion restriction may be more likely to be fulfilled, as culturally close countries are not necessarily in the immediate geographic vicinity. The creation of the instruments is described in detail in appendix A1.

The estimation strategy used in Table 3 follows Acemoglu et al. (2014) and Madsen et al. (2015), using 2SLS with cluster-robust standard errors including country-fixed and period-fixed effects.[23]

Panel A of Table 3 reports the 2SLS results, with first-stage outcomes presented in Panel B. The results from this exercise strongly support the positive effect of democracy found in Table (1). However, when instrumenting SVMDI with regional democratization waves, the reduced models imply an increase in the marginal effect of SVMDI from 0.0264 in the baseline specification to 0.293 in Table (3). The results also seem to be relatively unaffected by the classification of regions r, as both the categorization of the World Bank and the narrower concept yield outcomes strongly comparable in significance and magnitude. This also holds if we instrument the SVMDI variable by culturally-weighted waves of democracy. The marginal effect in the reduced model strongly resembles the effect detected in Column (1). As in the baseline estimations, the SVMDI ceases to be significant once the fertility rate is introduced in the model.[24]

Panel B highlights a strong effect of regional democratization waves in $t-1$ on national SVMDI scores, suggesting that Z_{it-1}^{r} is a valid instrument for SVMDI.[25] The first-stage regressions also highlight that $\tilde{Z}_{it-1}^{r}$ is less valid than Z_{it-1}^{r}. In the reduced model, cultural waves of democratization are significantly related to national democracy; however, the marginal effect is smaller compared to regional democratization waves. In the comprehensive model

[23] Whereas the authors in both studies use real per capita GDP as the dependent variable in their IV regression, the dependent variable in Table 3 again is the growth rate of real GDP per capita to ensure comparability with the baseline results. Note that exact replication with inclusion of SVMDI as democracy variable yields quite similar results. Note also that the results of a more direct comparison to the baseline table achieved by inclusion of our external instruments in the System GMM estimations strongly resemble the baseline findings.

[24] Similar to the baseline results reported in Table (1), SVMDI significantly contributes to income increases in each specification other than model (4).

[25] We instrument SVMDI by only one lag of Z_{it}^{r}. In accordance with Acemoglu et al. (2014), we find only slightly differing effects when using more lags of Z_{it}^{r} as instruments.

specification in the last column, we cannot find any contribution of cultural democracy waves on the SVMDI in country i.

Comparing the outcomes of Table (3) to a similar analysis conducted by Acemoglu et al. (2014), we find that utilization of SVMDI is superior to application of a rough dichotomous measure, as it yields much more significant results.[26] The reason for this is the substantial increase in the level of detail achieved by the Support Vector classification of the underlying data. Even when controlling for regional democratization waves, the strong heterogeneity in the subset of democratic (autocratic) countries—which necessarily occurs when conducting a binary classification—results in a loss of information that causes a distortion of the estimated results. Note also that the IV approach is likely to suffer from a Nickell bias unless the (bold) assumption holds that $\mathrm{E}[Z^r_{it-1}\varepsilon_{it}] = 0$ and ε_{it} is serially uncorrelated.

5.5 The effect of alternative democracy indicators on growth

Whereas the previous results provide strong evidence for a positive effect of democracy on growth when applying the SVMDI measure, we are interested in determining if these results are superior compared to estimations which use alternative indices of democracy. Whenever the available indices lack observations for recent periods (e.g. Vanhanen and Lindell, 2012) or have not yet been made available (e.g. Acemoglu et al., 2014), we calculate missing values according to the algorithms reported in the original documentations. We conduct two different estimation techniques, difference GMM and system GMM.

Difference GMM has been used in a number of recent studies (e.g. in Gerring et al., 2005 and Acemoglu et al., 2014). The general idea of this technique, shown in Equation (4), is to eliminate unobserved heterogeneity by first-differencing the specified model, i.e. first-differencing Equation (3). However, this transformation removes the information in the equation in levels, so that the estimation relies solely on the within-country information. In the context of the relationship between democracy and growth, this means that the estimated parameter essentially captures the effect of democratization *within*

[26] The same increase in significance occurs if we directly replicate the utilized specifications, using $\mathrm{Log}(\mathrm{GDP}_{pc})$ as dependent variable.

Table 3 The effect of SVMDI on growth, IV estimations. Dependent variable is real per capita GDP growth.

	Regional Democracy (World Bank)		Regional Democracy (Narrower definition)		Cultural Democracy (Culturally-weighted)	
	(1)	(4)	(1)	(4)	(1)	(4)
	Panel A: 2SLS regression results					
SVMDI	0.293***	0.224**	0.213***	0.119***	0.257***	0.0518
	(0.0747)	(0.109)	(0.0493)	(0.0429)	(0.0787)	(0.0496)
Log(GDP_{pc})	-0.0573***	-0.0684***	-0.0514***	-0.0683***	-0.0416***	-0.0539***
	(0.0124)	(0.0143)	(0.00939)	(0.0121)	(0.0146)	(0.00917)
INVS		0.0897*		0.0859**		0.0691*
		(0.0541)		(0.0433)		(0.0401)
SCHOOLY		0.00110		0.00219		0.00261
		(0.00341)		(0.00231)		(0.00203)
Log(LIFEEX)		0.142***		0.135***		0.113***
		(0.0454)		(0.0266)		(0.0430)
GOVC		-0.0391		-0.0282		-0.0466*
		(0.0412)		(0.0298)		(0.0260)
INFL		-0.000527		-0.000536		-0.000734
		(0.000617)		(0.000584)		(0.000803)
OPEN		-0.0172		-0.0107*		-0.00971
		(0.0109)		(0.00609)		(0.00651)
Log(FERT)		0.0000956		-0.0196		-0.0361***
		(0.0259)		(0.0147)		(0.0120)
	Panel B: First-stage regression results					
Democracy wave	0.41551***	0.30557**	0.47916***	0.37924***	0.2568***	0.05182
$(t-1)$	(0.1070)	(0.1221)	(0.9224)	(0.1051)	(0.0787)	(0.0495)
Observations	893	671	893	671	544	445
Countries	157	128	157	128	94	83
F p-val	0.00001	0.00000	0.00000	0.00000	0.00287	0.00000

Notes: Table reports 2SLS estimations, where SVMDI is instrumented by regional and cultural democracy. All estimations include country fixed effects, cluster robust standard errors in parentheses. Test statistics and number of included countries refer to Panel A. F p-val gives the p-value of the F Statistic of the reported model. Labels of the columns refer to the respective specification reported in the baseline estimations in Table 1. $*p < .10$, $**p < .05$, $***p < .01$.

Table 4 The effect of different democracy indicators on growth. Dependent variable is real per capita GDP growth.

	SVMDI	POLITY	VANHANEN	ACEMOGLU	FREEDOM	BOIX	UDS
	Panel A: Difference GMM estimations						
DEMOCRACY	0.0320**	0.000680	0.000860	0.00829	0.00851	0.00755	0.00850
	(0.0151)	(0.000918)	(0.000529)	(0.0116)	.00698	(0.0104)	(0.00723)
Observations	616	616	616	616	616	616	616
Countries	122	122	122	122	122	122	122
Hansen p-val	0.214	0.170	0.0968	0.221	0.210	0.199	0.226
AR(1) p-val	0.118	0.120	0.116	0.122	0.115	0.120	0.115
AR(2) p-val	0.229	0.240	0.237	0.229	0.220	0.231	0.236
Instruments	99	99	99	99	99	99	99
	Panel B: System GMM estimations						
DEMOCRACY	0.0161**	0.000972**	0.000684***	0.0119**	0.00585	0.00640	0.00698**
	(0.00751)	(0.00049)	(0.00026)	(0.00543)	0.00356	(0.0055)	(0.00336)
Observations	737	737	737	737	737	737	737
Countries	122	122	122	122	122	122	122
Hansen p-val	0.946	0.924	0.904	0.945	0.959	0.930	0.949
Diff-Hansen	1.000	1.000	1.000	1.000	1.000	1.000	1.000
AR(1) p-val	0.121	0.120	0.118	0.122	0.119	0.122	0.118
AR(2) p-val	0.345	0.348	0.352	0.342	0.337	0.344	0.346
Instruments	154	154	154	154	154	154	154

Notes: Table reports two-step system GMM estimations. All estimations use period fixed effects and Windmeijer-corrections, robust standard errors in parentheses. The instrument matrix is restricted to lag 3. Hansen p-val. gives the p-value of Hansen's J-test, AR(1) p-val. and AR(2) p-val. report the p-values of the AR(1) and AR(2) test. Diff-in-Hansen reports the C statistic of the difference in the p-values of the restricted and the unrestricted model. The unrestricted model ignores the Arellano and Bover (1995) conditions. $*p < .10$, $**p < .05$, $***p < .01$.

countries, i.e. the process of transformation towards more or less democracy. Panel A of Table (4) illustrates the results of the difference GMM estimations, replicating the specification of Column (3) in Table (2) using SVMDI and six commonly used democracy indicators. To exclude the possibility of a sample selection bias, the estimations rely on the intersection of observations that are available for all indicators. As in Section 5.3, the SVMDI detects a positive and significant effect of the democratization process within countries on their growth rate. However, neither of the alternative indicators suggests a similarly significant influence, a result which strongly resembles the effects found in many recent studies.[27] Since (non-)democratic countries differ in numerous historical, cultural, political, and institutional aspects, first-differencing

[27] Note that this result also occurs if we use other model specifications, e.g. Column (4) of Table (2) and Columns (2)–(4) of the baseline estimations of Table (1).

the model requires indicators that react quite sensitively to political events in order to capture the effect of transition towards democracy within countries. As illustrated in Section 4.4, hitherto existing democracy indicators are unable to react with sufficient sensitivity to political events and regime changes. For this reason, raw measures of democracy—particularly dichotomous indices—provide little indication of an income-enhancing effect of democratization, which is clearly visible in Table (4).

Since most of the variation of traditional democracy indicators stems from the cross-section rather than the time-dimension, the utilization of additional orthogonality conditions proposed by Arellano and Bover (1995) and Blundell and Bond (1998) is beneficial, as these additional restrictions ensure that some of the information of the equation in levels is maintained. With respect to the estimation of the democracy-growth nexus, this implies that the estimated parameters also capture the between variation, i.e. the variation in the level of democracy between the countries in the sample. In addition, as difference GMM requires information from at least three consecutive periods for a country to be included in the estimation, the exploitation of the Arellano and Bover (1995) orthogonality conditions also yields an increase in the number of observations. This is crucial, as we might expect loss of observations particularly for developing countries, which possess a higher within variation of democratization than advanced economies. Panel B of Table 4 reports the results of system GMM using the same model specifications as in Panel A. What we observe is a change in the picture. The SVMDI index maintains its positive and strongly significant effect on growth. Likewise, four of the six alternative indices now point to a similar influence of democracy on growth.

Overall, the results of Table (4) broadly indicate that democracy is positively related to growth. However, only the SVMDI indicates that the road to democracy is beneficial to growth. From an economic perspective, this implies that small steps towards democracy already lead to long-run increases in living standards, even if political rights in the countries do not catch up with those of established democracies. Conversely, reverse waves of democratization are always harmful to growth in the long-run. Once the econometric specification allows for the investigation of differences in the democracy level across countries, the positive effect of democracy can be observed as a clear empirical pattern, even if the model relies on raw measures of democracy.

6 The transmission channels of democracy

In line with Tavares and Wacziarg (2001), we previously suspected that political rights exert their influence on growth via a number of transmission channels. This section is concerned with a more in-depth analysis of these mechanisms. Table 5 illustrates the effect of democracy on schooling, investment, redistribution, and fertility. Each of these variables plays an important role in the growth progress; however, it is crucial to disentangle the effects of democracy from those of credit availability. Whereas democracy may raise schooling and investment via a more equal distribution of opportunities and less government interventions in the private sector, it simultaneously contributes to better credit availability. It has been emphasized in the growth literature that mitigation of credit market imperfections yields an increase in education and physical capital investments (see, e.g., Galor and Moav, 2004, Galor and Zeira, 1993). For this reason, we specify two models for each of the transmission variables: the first variant basically uses the variables of the specifications in Table (1), while the second variant additionally introduces private credit to GDP (CREDIT) as a proxy for credit availability.[28] As expected, the correlation between SVMDI and CREDIT is high (50 percent).

The empirical framework follows Acemoglu et al. (2014), conducting Within-Group (Panel A) and 2SLS (Panel B) estimations. The latter again uses regional waves of democratization as external instruments for domestic democracy. Due to the high probability of a potential Nickell (1981) bias in our "small" T panel, we do not include lagged dependent variables. SVMDI enters with a lag of one period in the regressions to ensure that causality runs from democracy to the transmission variables, rather than the reverse.

The first transmission channel in Table 5 is concerned with education. The results imply that richer economies exhibit a higher average level of school attainment. In addition, better health as measured by life expectancy enhances education. The trade-off between the quantity and the education of children is clearly visible, as we can observe a significantly negative impact of fertility on education. Controlling for these effects, the influence of democratization is positive in the Within-Group estimations and becomes significant in Column (2) when we introduce CREDIT. Likewise, SVMDI is significant in both specifications of the 2SLS estimations. The results imply that bet-

[28] The data source is World Bank (2014b).

Table 5 The transmission channels of democracy

	Schooling		Investment		Redistribution		Fertility	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
	Panel A: Within-Group regression results							
Log(GDP$_{pc}$)	1.036***	0.650***	0.00803	0.0000725	0.000969	-0.00556	0.00845	-0.0501
	(0.189)	(0.183)	(0.0223)	(0.0234)	(0.00606)	(0.00553)	(0.0347)	(0.0333)
SVMDI($t-1$)	0.202	0.293*	0.0294**	0.0295*	0.00178	0.000810	-0.114**	-0.0522
	(0.185)	(0.161)	(0.0132)	(0.0151)	(0.00379)	(0.00429)	(0.0453)	(0.0364)
INVS	-0.166	-0.327			-0.0781***	-0.0783***	-0.310**	-0.370***
	(0.702)	(0.701)			(0.0216)	(0.0220)	(0.148)	(0.138)
SCHOOLY			0.000906	-0.00284	0.00571***	0.00492***	-0.115***	-0.120***
			(0.00552)	(0.00594)	(0.00152)	(0.00140)	(0.0165)	(0.0166)
Log(LIFEEX)	2.585***	2.123**	0.230***	0.229***	0.0300**	0.0263**	-0.210	-0.192
	(0.961)	(0.848)	(0.0729)	(0.0768)	(0.0140)	(0.0131)	(0.160)	(0.151)
GOVC	-0.729	-0.632	-0.107	-0.126	0.00198	0.00242	0.0972	0.0950
	(0.720)	(0.689)	(0.0920)	(0.0862)	(0.00904)	(0.00880)	(0.109)	(0.0985)
INFL	-0.0139**	-0.0108	-0.000165	-0.00119*	0.000405	0.000387	0.00034	0.00072
	(0.00668)	(0.00727)	(0.00134)	(0.000601)	(0.000275)	(0.000307)	(0.0007)	(0.0006)
Log(FERT)	-2.710***	-3.022***	-0.0633**	-0.0810***	0.0162**	0.0125*		
	(0.306)	(0.296)	(0.0294)	(0.0296)	(0.00679)	(0.00654)		
OPEN	0.107	0.122	-0.00218	-0.00359	0.00524	0.00469	0.00246	0.0112
	(0.123)	(0.112)	(0.0105)	(0.00979)	(0.00348)	(0.00334)	(0.0221)	(0.0189)
CREDIT		0.688***		0.00757		0.0126**		0.122***
		(0.220)		(0.0185)		(0.00581)		(0.0434)
REDIST			-0.683***					
			(0.189)					
	Panel B: 2SLS regression results							
SVMDI($t-1$)	2.052***	2.192***	0.0755*	0.0867	0.0161	0.0162	-0.469***	-0.420**
	(0.706)	(0.713)	(0.0424)	(0.0539)	(0.0107)	(0.0125)	(0.146)	(0.174)
Observations	670	648	560	648	560	544	670	648
Countries	128	126	121	126	121	119	128	126
R-squared	0.607	0.645	0.240	0.200	0.130	0.150	0.532	0.568
F-statistic	43.10	46.57	7.454	8.023	3.545	3.307	28.59	29.24
Model p-val	1.23e-30	6.06e-34	4.94e-08	1.08e-08	0.00102	0.00124	2.52e-23	2.99e-25

Notes: Table reports Within-Group and 2SLS estimations. Model specification of the 2SLS estimations is identical to the Within-Group variant. Cluster robust standard errors in parentheses. Test statistics refer to the Within-Group models. F statistic reports the test statistic of joint significance of the model, Model p-val gives the p-value of the F-test. $*p < .10$, $**p < .05$, $***p < .01$.

ter credit availability softens the budget constraints of the household, thereby contributing to a higher level of education of individuals. However, even when controlling for this effect, the impact of democracy acts as an additional source of educational improvements.

The second transmission channel illustrates the effect on investment, which is positive in both the Within-Group and the 2SLS estimations. Apparently, democratic structures and political rights facilitate both national and foreign investments and capital inflows. These findings are in line with the well-known results of Perotti (1996), who finds that political stability—which is considerably larger in democracies (Feng, 1997)—has a huge impact on investment and growth. CREDIT has no significant effect on investment, suggesting that the positive contribution of the SVMDI stems largely from foreign investments, which are not necessarily financed by loans acquired in the target country. To examine a possible negative effect of increasing political rights in countries with a medium or high level of SVMDI, Column (1) also incorporates the level of effective redistribution measured by the difference of the Gini coefficient of household incomes before and after taxes and transfers.[29] The results show a strongly significant impact of redistribution on investments, where a higher amount of redistribution is negatively related to investment activity. This, in principle, supports the hypothesis that a higher level of democratization may be an impediment to growth. However, this mechanism only comes into play if democracy enhances redistribution.

This effect is investigated in the third branch of transmission analysis. We observe that redistribution is lower in countries with a higher average level of education. Meanwhile, countries with higher life expectancies, higher government consumption and higher fertility rates typically tend to redistribute more. Controlling for these effects, we find no additional contribution of SVMDI on redistribution, neither in the Within-Group regressions nor in the 2SLS estimations. This implies that the strong bivariate correlation between SVMDI and REDIST (63 percent) is not due to an inherent causality running from democracy to redistribution, but is the result of numerous variables that are affected by democracy. The ambiguous effect of democracy on redistribution strongly resembles the recent findings of Acemoglu et al. (2013). However, Feld and Schnellenbach (2014) emphasize that the manner in which income is redistributed differs between countries, depending on the respective constitutional

[29]Data source is the SWIID v5, documented in Solt (2009) and Solt (2014).

framework.

The last transmission channel refers to the effect of democracy on fertility. The first column highlights that democratization yields a significant decline in fertility rates. The process of democratization is often accompanied by a substantial increase in social security systems and a reduction of uncertainty due to higher political stability, both of which reduce families' incentives to have children as a substitute for social protection. However, it is crucial to disentangle the different effects of democracy and credit availability, as illustrated in Column (2). When holding constant CREDIT, the effect of democracy shrinks, but remains negatively and—in case of the 2SLS estimations—significantly associated with fertility. Better credit availability increases the fertility rate, as access to capital markets alleviates the otherwise binding trade-off between the quantity and the education of children.

Summarizing the findings, we observe that democracy exerts its influence on growth via better education, higher investment shares, and lower fertility rates. In contrast, we find no evidence for a redistribution-enhancing effect of democratization.[30]

7 Conclusions

Having reliable measurements regarding democracy is essential for achieving a sound understanding of democratization and its effects on political and economic outcomes. The overwhelming majority of existing indicators, however, are fraught with methodical problems. Scholars using such rough measurements will find, not infrequently, that an inappropriate democracy indicator is the Achilles' heel of empirical analyses, particularly when working with panel data.

By maximizing comparability for the broadest possible sample of countries, the SVMDI algorithm facilitates empirical investigations of democracy. A direct result of this methodical progress is a substantial increase in the level

[30] We also do not find any robust effect of democracy on health, even though both variables reveal a high bivariate correlation (53 percent). What we do find, however, is a significant impact of initial wealth on life expectancy. Whereas we would suspect that democratic countries provide better public health services, the estimations imply that incomes are much more decisive for health than regime types. However, life expectancy may be a poor proxy in this context, as changes in this variable may only occur a considerable amount of time after democratization has taken place.

of detail in comparison to established approaches. In addition, the algorithm places the crucial question of how to aggregate the underlying attributes—undoubtedly the main weak point of alternative indicators—into the context of a nonlinear optimization problem, thereby obtaining much more consistent and plausible results. The unprecedented potential of machine learning enables researchers to make highly accurate classifications, and may also yield very promising results for problems in the field of economics beyond its utilization for measuring democracy.

Using the SVMDI, we find a robust positive influence of democracy on long-run economic growth. Our results imply that the ambiguity in recent studies stems from two main sources. First, in light of the diversity of political institutions across countries, the lack of a sufficient reaction of traditional democracy indicators to political events and regime changes only allows for a rough classification of democracy. Second, when using empirical models that rely on the within-country variation, the problem of inadequate and insensitive measurement of democracy becomes particularly severe.

When digging deeper into the democracy-growth nexus, we find only little indication of a nonlinear relationship between the variables. The analysis of the transmission channels through which democracy exerts its influence on growth illustrates why: whereas democratic countries typically have more educated populations, higher investment shares and lower fertility rates, we cannot find evidence of a redistribution-enhancing effect of democratization.

Taken together, our results emphasize that democratic structures facilitate economic growth in the long-run, and their implementation may be a beneficial strategy for less-developed countries. However, countries differ in numerous cultural, historical, political, and institutional dimensions. Isolating the growth effect of different aspects of democratic institutions may thus be an advantageous field of future research. Likewise, it would be beneficial to acquire a deeper empirical understanding of the transmission channels of democracy, particularly with regard to health, inequality, and redistribution.

Appendix

Appendix A1: Description of the external instruments used in the IV regression

Let $\mathcal{R} = \{1, ..., R\}$ denote a set of regions, where each country i belongs exactly to one region r. In addition, let N_{rt} be the number of countries in region r at period t and d_{it} denote the level of democracy in country-year $\{i, t\}$. Then the regional democratization wave—i.e. instrumental variable Z_{it}^{r}—is calculated via

$$Z_{it}^{r} = \frac{1}{N_{rt} - 1} \sum_{\{j | r' = r, r' \in \mathcal{R}\}} d_{jt}.$$

To build the cultural weighted instrumental variable of democracy, we use four of the cultural dimensions—*Power Distance* (PD), *Individualism* (IN), *Masculinity* (MC), and *Uncertainty Avoidance* (UA)—provided by Hofstede (2001) and calculate our instrument via a four-stage approach. First, we calculate the Euclidean distance

$$\delta_{ij} = \sqrt{(PD_i - PD_j)^2 + (IN_i - IN_j)^2 + (MC_i - MC_j)^2 + (UA_i - UA_j)^2} \tag{5}$$

for each set of countries $\{i, j\}$. Subsequently, we normalize δ_{ij} to the interval from 0 to 1 by applying the standard formula

$$\bar{\delta}_{i,j} = \frac{\max_{i,j}\{\delta_{i,j}\} - \delta_{i,j}}{\max_{i,j}\{\delta_{i,j}\} - \min_{i,j}\{\delta_{i,j}\}}, \tag{6}$$

which is used, for instance, for generation of the Human Development Index (see United Nations, 2013). In the third stage, we calculate the cultural weights $\lambda_{i,j}$ via

$$\lambda_{i,j} = \frac{\bar{\delta}_{i,j}}{\sum_{k \neq i} \bar{\delta}_{i,k}} \tag{7}$$

to ensure that the weights sum up to 1 for each country i. Finally, the external instrument $\tilde{Z}_{it}^{r}$—which equals the cultural weighted democracy score for a certain country-year $\{i, t\}$—is computed as follows

$$\tilde{Z}_{it}^{r} = \sum_{k \neq i} \lambda_{k,t} \mathrm{SVMDI}_{k,t}. \tag{8}$$

Table A2 Classification of regions in the IV regression.

I. ASIA	
Central Asia	Afghanistan, Armenia, Azerbaijan, Bhutan, Georgia, India, Iran, Kazakhstan, Kyrgyzstan, Maldives, Mongolia, Nepal, Pakistan, Sri Lanka, Tajikistan, Turkmenistan, Uzbekistan
East-Southeast Asia	Bangladesh, Cambodia, China, Japan, Laos, Myanmar, North Korea, South Korea, Taiwan, Thailand, Vietnam
Arabic Region	Bahrain, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates, Yemen
Oceania	Australia, Brunei Darussalam, Fiji, Indonesia, Malaysia, New Zealand, Papua New Guinea, Philippines, Samoa, Singapore Solomon Islands, Tonga, Vanuatu
II. EUROPE	
Central-Northern Europe	Austria, Belgium, Denmark, Finland, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Sweden, Switzerland, United Kingdom
South-Southwest Europe	Cyprus, France, Greece, Italy, Malta, Portugal, Spain
East Europe	Belarus, Czech Republic, Estonia, Latvia, Lithuania, Moldova, Poland, Russia, Slovakia, Ukraine
Balkan States	Albania, Croatia, Bulgaria, Hungary, Kosovo, Macedonia, Montenegro, Romania, Serbia, Slovenia
III. AFRICA	
North Africa	Algeria, Egypt, Libya, Morocco, Tunisia
Central-East Africa	Cameroon, Central African Republic, Chad, Djibouti, Eritrea, Ethiopia, Kenya, Somalia, South Sudan, Sudan
West Africa	Benin, Burkina Faso, Cape Verde, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo
Southern Africa	Angola, Burundi, Comoros, Democratic Republic of the Congo, Republic of the Congo, Equatorial Guinea, Gabon, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Rwanda, Sao Tome and Príncipe, Seychelles, South Africa, Swaziland, Tanzania, Uganda, Zambia, Zimbabwe
IV. AMERICA	
North America	Bahamas, Canada, United States
Central America	Belize, Costa Rica, El Salvador, Grenada, Guatemala, Honduras, Mexico, Nicaragua, Panama
South America	Argentina, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela
Caribbean	Antigua and Barbuda, Barbados, Cuba, Dominica, Dominican Republic, Haiti, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent, Trinidad and Tobago

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