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“What Drives Biodiversity? An Empirical Assessment of the Relation between Biodiversity and the Economy”*

by Andreas Freytag, Christoph Vietze, and Wolfgang Völkl

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Abstract

The environmental discussion is increasingly extended to the question of how to preserve biodiversity. As sensible regulation of biodiversity utilization uses politically set incentive schemes, it is required to discuss the monetary value of biodiversity. Consequently, the relation between economic incentives and biodiversity is in the focus of our paper. By using bird species as bio indicators we derive first empirical results. In sum, one still may conclude that indeed economic growth is harmful for biodiversity. This is at least in line with the first part of biodiversity Kuznets curve. However, the existence of good institutions (especially a high quality of regulation) can in part prevent this effect, which can be cautiously interpreted as a hint that economic growth is not necessarily related to losses of biodiversity. With good governmental institutions, these losses may be prevented or mitigated.

JEL-Classification: O13, Q27

Key words: economic growth, institutions, development, biodiversity, cross country analysis

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1. Introduction

The environmental discussion is increasingly extended to the question of how to preserve biodiversity. Interestingly, it is no longer politically incorrect to discuss the monetary value of biodiversity, as the literature on ecosystem services shows. In addition, an increasing awareness of the competing demands for these services have shown politicians, scientists and the public the necessity to evaluate biodiversity and discuss alternative uses. These demands are steered by politically set incentive schemes. On the side of natural scientists, the former rejection of economic judgement – often discarded as heartless business, greed or political power games – has given way to the insight that economic thinking may well be instrumental for biodiversity preservation. In particular, it is no longer questioned that property rights on environmental goods play a major role for this target.

Consequently, the exact relation between economic incentives and biodiversity has received an ever increasing attention in the literature, and not only so in the economic literature. The first problem is to define and measure biodiversity, so that property rights can be assigned. Such a task is heroic, as it requires an enormous input. Some authors therefore have taken recourse to assess the attitude towards biodiversity (Mozunder et al. 2006) or the surface of protected area (Schubert and Dietz 2001) as proxies. We choose a different variable used e.g. by Naidoo and Adamowicz (2001, 2005a, b), Asufu-Adjaye (2003), or Freytag and Vietze (2009), namely the number of breeding and living bird species in a country or a region. Second, the definition of ecosystem services, which is the monetary value of biodiversity, is difficult. Ecosystem services comprise of direct goods such as food and fresh water, regulating services such as climate regulation, supporting services such as soil formation, and finally cultural services such as education (Forest Trends et al. 2008, p. 2). Whereas the first group can be valued with a positive price due to scarcities and production costs, the other three service types are hard to estimate in value.

However, it would be invaluable to be able to give these service a relative price, as that would enable the society to calculate opportunity cost of individual and public actions. To approach this target, this paper takes a first step and forms an attempt to assess the relationship between biodiversity and socio-economic indicators. The question we address is to what extent the level of biodiversity in a country is correlated with the economic development and institutional setting of this country. While we are aware of the fact that we cannot derive dynamic interpretations with respect to the “correct” development path, we are sure to contribute to a better understanding of this relationship in general. Based on empirical evidence, it may become possible to define and take measures to foster sustainable growth.

The remainder of the paper is organised as follows. In the next section, we briefly explore the theoretic relations between the socio-economic and institutional setting in a country and the degree of biodiversity. In section 3, we discuss the case for using bird species. Section 4 is dedicated to the empirical analysis, section 5 concludes.

2. Theoretical considerations and hypotheses

Although the state of nature is not only influenced by mankind, it is sensible to assume that the degree of biodiversity is to a great extent driven by human activities. In particular, the dynamic interaction between the economy and nature is of interest here. In environmental economics, the idea of the Kuznets curve has been used to explain the environmental quality in a country dependent on the state of its development. The original Kuznets curve is arguing with an inverted U-shaped relationship between distribution and GDP per capita. Its application to the environment – the environmental Kuznets curve, EKC – argues similarly. A growing economy causes environmental degradation as long as GDP per capita is low, as there is a scale effect on the environment. With higher GDP per capita the structure of the economy tends to change from industrial to service orientation, which serves the environment. A third technique effect is due to technological change, which encourages the use of clean technologies. Another important driver of the EKC is income elasticity: with increasing income, the demand for clean nature increases. However, one can imagine that environmental degradation increases again after the GDP per capita exceeds a certain threshold, as the scale effect is dominating. The EKC then has an N-shape. Empirical evidence so far is not convincing in the sense that the U-shaped EKC could be confirmed (Borghesi 2002).

In general however, it is somehow questionable to transfer the concept of the EKC to biodiversity. The reason for this caution is that whereas the quality of a river may increase after economic activities change, an extinct species is lost for ever. Thus, the biodiversity Kuznets curve (BKC) may be a falling curve, implying that neither structural change or the technique effect, nor income elasticity of demand for biodiversity can change this (Schubert and Dietz 2001, pp. 13-18). Whereas this argument holds on a global scale, it may be different on a local, regional and even national scale. It may well be that a species is extinct in Germany, but not so in Slovenia. If nature recovers due to the EKC, this species may remove to Germany. Biodiversity increases again, and the BKC is (at least partly) valid. Thus, we derive two hypotheses from these considerations¹:

- 1) Biodiversity on the country level is negatively correlated with growth of GDP per capita.
- 2) It is weakly positively correlated with GDP per capita.

These two hypotheses are accompanied by another related logic. It may be the case of two countries with similar GDP per capita or similar growth experience. They also face similar natural conditions (e.g. size, relief, and distance to the equator). Despite these similarities, there may be assumed differences in biodiversity. The reason for these differences may be found in the political or institutional setting. McNeely (1996, p. 40) argues that the politically set incentive structure supported biodiversity depleting activities. We take up his argument and argue that these incentives are given in a country with low institutional quality, which implies corruption being high, the rule of law being hurt, government effectiveness being low, political stability being low, regulatory quality being low and the chances to express ones opinion also being low (Kaufmann et al. 2006). In addition, following the logic of Coase (1960), the definition and assignment of property rights is crucial. Without individual property rights, biodiversity does not receive a positive price (Freytag and Vietze 2009). Similarly, Accemoglu et al. (2001) use differences in mortality rates among European settlers to estimate the effect of institutions on economic performance in colonies. If settlers applied only a *hit-and-run* strategy to exploit resources (which is related with high short-term growth and less growth in the long-run and decreasing environmental quality) they do not establish institutions; whereas institution building leads to long-term economic growth (and a lesser exploitation of the environment). Nevertheless, incentives to take biodiversity into considerations are low. Thus, we formulate two additional hypotheses:

- 3) Institutional quality is positively correlated with biodiversity.
- 4) Property rights are positively correlated with biodiversity.

In the following section, we introduce our measure of biodiversity before in section 4 the hypotheses are tested empirically.

3. Birds as bio-indicators

Birds are excellent bio-indicators for an analysis between economic activities and biodiversity (Riecken 1992, DO-G 1995, Boening-Gaese and Bauer 1996, Plachter et al. 2002, Gregory

¹ Ideally, one would investigate the development of the biodiversity level directly over time. Unfortunately however, this is not possible as the continuous and nationwide counting of our biodiversity indicator has not been started before the year 1994 (BirdLife International 2008a).

et al. 2003, BirdLife International 2004, Naidoo and Andamowicz 2005a), especially for studies on a global scale (Bibby et al. 1992, Burgess et al. 2002). First, birds may represent the best-known animal taxa. Species numbers are available for almost all countries, and additionally for other political units or for geographical units (e.g. Wolters 1982; Clements 2007). Thus, a worldwide comparison can be easily based on current and sufficient information.

Second, the vast majority of bird species needs large home ranges (in comparison to invertebrates). They also require complex habitats with specific habitat structures and equipments for the distinct parts of their life cycle. Among those factors are nesting and breeding sites, hiding-places or specific mating sites. Thus, most species respond very sensitively to changes in their habitat. Such changes may include habitat loss (either complete habitats, or specific sites) due to economic efforts, but also regular disturbances and interferences with human visitors, especially at breeding sites. By contrast, many species also respond positively to conservation measures, showing that habitat loss might be reversible. However, some species only occur in primary habitats (e.g. native primary rainforest), and these species can only be supported and protected by a strong protection of the remaining sites.

Third, a sufficient food supply is the base for supporting the long-term survival of a population. This is especially obvious for all carnivores, which represent top positions in the food chain. These species need complexly structured habitats fulfilling both their own requirements and those of their prey, which has to maintain high population densities. However, specific food supply may be also a critical factor for other specialised species with a narrow food range.

Fourth, the number of bird species can not be politically instrumentalized (Metrick and Weitzman 1998; Rawls and Laband 2004), as long as the counting is done independently.

Consequently, many bird species are considered as "flagship species" whose presence indicates the presence of a species rich animal and plant community (e.g. Primack 1993, Lawton et al. 1998). An alternative to the use of the number of species for monitoring changes in biodiversity is a biodiversity index relying on individual countries' richness as favored by Magurran (2004) and by Bruckland et al. (2005). The theoretical rigor of their argument is convincing, but our indicator (BIRDS) may represent the best-known animal taxon, and an avifauna is usually available not only for countries, but also for other geographical or political units. Thus, we use this information to form three endogenous variables: the variable Bird Species is expressed as number of bird species living in the respective country (table 1) as well as the same number in relation to country size (birds per sqkm, table 2). In addition to these variables, we calculate the ratio of endangered bird

species to all bird species in a country (tables 3 and 4). The list of endangered birds is applied world-wide. Therefore, even if some distortions are in the list, this holds for all countries similarly. The latter two variables are statistically not interdependent. The data are from 2005, as documented by BirdLife International (2005).

4. The empirical assessment

a) Data and methodical considerations

To test the hypotheses, exogenous variables have to be defined and other exogenous control variables have to be added. The explanatory variables are the following:

- the rate of annual GDP growth in percentage from 1980 till 2005 (Δ GDP 80-05), source is IMF (2006) → hypothesis 1),
- the GDP per capita in US-\$ (purchasing power parity) of the year 2005 (GDP 2005), source is IMF (2006) → hypothesis 2),
- the World Bank governance indicators in 2005 for Control of Corruption (CCORR), Government Effectiveness (GOVEFF), Political Stability (POLSTAB), Quality of Regulation (REGQUAL), Rule of Law (LAW) and Voice and Accountability (VOICE); all of these also as proxy for the institutional quality of a country, source is Kaufmann et al. (2006) → hypothesis 3),
- the Human Development Index (HDI), respectively the HDI sub indices for the educational level (HDI educ), the per capita income (HDI gdp), and the live expectancy (HDI lifeexp) in 2005 as proxy for the development level of a country, source is Human Development Report 2005 → hypotheses 2 and 3),
- the ratio of IUCN category I-IV protected areas per total land area of the country (IUCN) as an additional proxy for assigned property rights of biodiversity to public land owners, source is WRI (2006) → hypothesis 4).

Control variables are usual ones:

- the size of the country (SIZE) in sqkm, source is CIA (2005),
- the distance of the country to the Equator in grad (EQ) as a proxy for differences in climate, source is CIA (2005),
- the population density of the country (POPDENS), expressed as the number of population per country size as proxy for anthropogenic ground sealing, source is Heston et al. (2006),

- a dummy for a country being an island (ISLAND), as proxy for geographic insularity, source is CIA (2007),

Because it is apparent that the sample does not have disturbances with identical variance, we generally run a White-Heteroskedasticity Residual Test and use an adjusted OLS-estimator robust to heteroskedasticity in all estimations. Another problem may be multicollinearity, in particular high correlation between the World Bank governance indicators as control variables. To avoid this problem, we do not use all indicators simultaneously. Including a set of dummies and time invariant variables (above all the explanatory variables bird species and ratio of endangered bird species which are counted in a four year frequency (BirdLife International 2008b)) in our estimation model, a country fixed effects panel estimation cannot be applied. Additionally, a panel model is also not possible, regarding low time series data availability (EQR, SIZE). As it is our intent to explain the heterogeneity in the biodiversity endowment within the world with exogenous socio-geographic variables, we cannot apply the 'fixed-effects modeling [as] a result of ignorance' (Cheng and Wall 2005, pp. 54). Instead, according to Wei and Frankel (1997), we endeavor to estimate the exact effects of geographical variables (EQR, SIZE, ISLAND) that are time constant. The inclusion of country dummies will undermine these efforts because the time-constant geographical variables are hidden from analysis as they are subsumed into the fixed effects (see also Vietze 2008). A widely described problem in pooled panel estimations, with respect to fixed effects estimations, is the problem of omitted variables (e.g. Cheng and Wall 2005). However, because of the structure of our data, we must include country and time constant variables (Bird species, EQR SIZE, and ISLAND). Thus, including data from 208 countries (see Appendix B) we use an ordinary least square cross country estimation model.² The fact that not all data are available for every single country reduces our sample size in most of our regressions.

b) Estimations and discussion

We test the hypotheses in three steps. First we assess the impact of the exogenous variables on the absolute number of bird species in a country across more than 160 countries. The results are displayed in table 1.

² Due to data availability some countries must be excluded in the respective regressions.

Table 1: Absolute Biodiversity and Economic Variables

	I	II	III	IV	V
CONST	689.58*** (15.608)	682.32*** (14.792)	586.87*** (9.666)	542.21*** (9.101)	690.93*** (12.032)
ΔGDP 80-05	-0.068*** (-2.847)	-0.060* (-1.973)	-0.076*** (-3.037)	-0.051* (-1.792)	-0.068 (-1.564)
GDP 2005		-0.0009 (-0.554)			
HDI			258.92* (1.787)		
HDI educ				447.41*** (3.056)	
HDI gdp				-312.65* (-1.853)	
HDI lifeexp				103.86 (0.863)	
REGQUAL					1.086 (0.042)
SIZE	8.67E-05*** (5.106)	8.74E-05*** (5.337)	8.36E-05*** (4.877)	8.52E-05*** (5.281)	8.67E-05*** (7.645)
ISLAND	-270.77*** (-6.193)	-265.57*** (-5.739)	-295.52*** (-5.752)	-295.44*** (-5.735)	-271.42*** (-6.026)
EQR	-11.721*** (-6.531)	-9.182*** (-7.379)	-11.721*** (-6.531)	-11.441*** (-6.647)	-9.643*** (-6.655)
POPDENS	-0.048*** (-5.416)	-0.045*** (-4.215)	-0.062*** (-5.367)	-0.053*** (-5.090)	-0.048* (-1.856)
IUCN	7.962*** (4.178)	8.081*** (4.209)	7.072*** (3.867)	6.894*** (3.881)	7.946*** (5.104)
R²adj	0.5756	0.5733	0.5819	0.5962	0.5729
N	163	163	161	161	163

Dependent variable is the absolute amount of bird species.

Absolute t-values in parenthesis.

* Significant at the 90 percent level.

** Significant at the 95 percent level.

*** Significant at the 99 percent level.

According to table 1, the number of birds in a country indeed depends on several political and natural factors. The socio-economic variables derive interesting results. First, while the GDP per capita in a respective country is not significant, the GDP growth rate (1980 until 2005) shows a strict negative sign. So it can be considered that economic growth harms the species richness in general. If we add the HDI index as indicator for the level of the country's development one can see that development is positive for biodiversity. By splitting the HDI index into the sub indices for the educational level, the per capita income, and life expectancy it is apparent that indeed per capita income is negative for the species richness, while the educational level seems to raise the awareness of the mankind to protect the

nature. The institutional indicator show insignificant results (we only display REGQUAL), but having the consequence that GDP growth and population density become insignificant.³ Not astonishing, well-defined property rights are crucial, as the nature protection areas (in relation to country size) (IUCN) show a positive and strictly significant sign. Concluding, it can be considered that the hypotheses cannot be fully rejected, except for GDP that is only weakly negatively correlated with biodiversity, the other variables rather significantly. A lacking significant negative correlation (although there is a pronounced trend) between economic development or the governance indicators and bird species number may be partially explained by differences in the knowledge on bird fauna and by some outliers. First, the bird fauna may be recorded incompletely in poor countries with mostly a weak institutional quality. This factor might be most pronounced in areas with a general high biodiversity and extended areas with native forest (e.g. some countries in West Africa or Laos and Kampuchea). Also, the proportion of poor countries increases with decreasing distance to the equator, while the knowledge on (or the completeness of) bird fauna is decreasing. Second, some countries with an exceptionally high biodiversity (Brazil, India) and a very good knowledge on bird and mammal fauna may have had an enormous economic development (and reasonable good governance structures too) and therefore a high GDP growth. Both factors, which point in opposite direction, may mask the correlation between GDP and bird and mammal species richness. However, a high GDP growth rate is harmful for the country's biodiversity but a high level of development is not, but also not beneficial.

To proceed with the controls, they are behaving as suggested by the theory: the area of a country (SIZE) is one of the most important predictor for its species richness. In general, large countries provide habitats for a significantly higher species number than small countries, a phenomenon following the classical "island theory" (MacArthur and Wilson 1967). This effect is less significant if only "threatened species" are considered (tables 3 and 4). However, this finding may result from the fact that threatened species may be overrepresented on small island countries, such as the Caribbean countries, the Indian Ocean countries (Seychelles, Comoros, Mauritius) or Pacific island countries (Tonga, Fiji, Samoa) (IUCN 2008). The "island country factor" can be also easily explained. In general, many island countries have a small area (e.g. in the Caribbean, the South Pacific and the Indian Ocean) and thus provide less habitat to support a species-rich bird fauna and avifauna. Additionally, many bird taxa did not colonize small islands, and many ocean islands are dominated by few marine bird species. Exceptions are the large island countries such as Indonesia and the Philippines (where many islands count together) and New Guinea. By contrast, even small countries on continents may benefit from large species-rich

³ We left all other regression with institutions out of table 1.

neighbouring countries. Here, species may pass during migrations or dispersal, or their population range may include small border areas or neighbouring countries. This effect is especially obvious in West Africa, where many small countries share a similar avifauna. The interactions between the number of threatened species and the "island factor" have been discussed above.

There is a second geographical aspect: The diversity of birds increases with decreasing latitude, i.e. with the distance to the equator. This effect is especially obvious in small species with a high number of taxa, such as passerine birds and rodents, where diversity reaches a maximum around the equator. The missing significance between latitude and "number of threatened species" can be easily explained by a missing data base for many species dwelling in equatorial rainforests or other ecosystems in remote areas. Further, a high population density (POPDENS) affects biodiversity negatively as this goes along with anthropogenic ground sealing.

The next step is to normalise the number of species by relating it to the countries' sizes. Whereas both growth and income variables become insignificant, the institutions are relevant; this is exactly what we observed in table 2. Property rights still matter. Size is no longer relevant, all other controls remain significant. The interim result holds so far.

Table 2: Birds per sqkm, Economic Development and Institutions

	I	II	III	IV	V	VI	VII	VIII	IX	X
CONST	0.028* (1.717)	0.034* (1.795)	-0.039* (-1.923)	-0.044* (-1.906)	0.073*** (2.640)	0.082*** (2.814)	0.064** (2.517)	0.080*** (2.901)	0.074** (2.538)	0.061** (2.283)
ΔGDP 80-05	9.37E-06 (0.889)	2.47E-06 (0.187)	-5.81E-06 (-0.508)	3.01E-06 (0.229)	9.94E-06 (0.472)	5.81E-06 (0.276)	1.24E-06 (0.059)	8.46E-06 (0.405)	5.60E-06 (0.264)	1.66E-05 (0.774)
GDP 2005		8.25E-07 (1.114)								
HDI			0.159** (2.530)							
HDI educ				0.086 (1.462)						
HDI gdp				0.069 (1.213)						
HDI lifeexp				0.074 (0.193)						
CCORR					0.034*** (2.917)					
GOVEFF						0.038*** (3.002)				
POLSTAB							0.036*** (3.241)			
REGQUAL								0.042*** (3.333)		
LAW									0.033** (2.580)	
VOICE										0.029** (2.450)
SIZE	-3.96E-09 (-1.510)	-4.54E-09* (1.683)	-5.77E-09** (-2.063)	-5.68E-09** (-2.004)	-5.46E-09 (-0.993)	-6.30E-09 (-1.141)	-3.08E-09 (-0.566)	-5.74E-09 (-1.052)	-5.13E-09 (-0.927)	-4.82E-09 (-0.871)
ISLAND	0.125*** (3.747)	0.120*** (3.649)	0.105*** (3.403)	0.106*** (3.393)	0.099*** (4.448)	0.098*** (4.415)	0.095*** (4.253)	0.100*** (4.560)	0.098*** (4.214)	0.100*** (4.356)
EQR	-0.0007* (-1.860)	-0.0011** (-1.994)	-0.0019** (-2.536)	-0.0020** (-2.526)	-0.0020*** (-2.821)	-0.0022*** (-2.974)	-0.0951*** (-2.634)	-0.0022*** (-3.095)	-0.0019*** (-2.659)	-0.0016** (-2.438)
POPDENS	6.26E-05*** (3.344)	5.98E-05*** (3.147)	5.44E-05*** (2.999)	5.52E-05*** (3.073)	5.00E-05*** (3.987)	4.84E-05*** (3.824)	5.50E-05*** (4.612)	4.73E-05*** (3.771)	5.13E-05*** (4.071)	5.85E-05*** (4.885)
IUCN	-0.0009 (-1.548)	-0.0010 (1.579)	-0.0014* (-1.916)	-0.0014 (-1.906)	-0.0013* (-1.770)	-0.0015 (-1.930)	-0.0010 (1.333)	-0.0015 (-2.008)	-0.0013* (-1.735)	-0.0014* (-1.832)
R²adj	0.3295	0.3019	0.3185	0.3114	0.3357	0.3377	0.3437	0.3461	0.3281	0.3254
N	163	163	161	161	163	163	163	163	163	163

Dependent variable is all bird species per sqkm. Absolute t-values in parenthesis.

* Significant at the 90 percent level.

** Significant at the 95 percent level.

*** Significant at the 99 percent level.

In a third stage, we investigate how the ratio of endangered biodiversity (the ratio of endangered bird species to all bird species) is affected by the same socio-economic variables as above. Although most of our results in table 3 are not significant, one can derive some interesting results. A high per capita income (also as measured as HDI sub index) is obviously helpful in reducing endangered biodiversity. The other significant variables show the same impact (the opposite sign) as above. Especially a high population density causes the endangerment of biodiversity.

Table 3: Ratio of Endangered Biodiversity and Economic/Institutional Variables

	I	II	III	IV	V	VI
CONST	0.048*** (4.603)	0.039*** (3.700)	0.032** (2.334)	0.027** (2.278)	0.037*** (3.070)	0.036*** (2.918)
AGDP 80-05	-2.08E-06 (-0.365)	6.71E-06 (0.964)	-3.11E-06 (-0.559)	7.16E-06 (1.159)	-2.22E-06 (-0.363)	-1.87E-06 (-0.301)
GDP 2005		-1.05E-06*** (-2.963)				
CCORR					-0.008 (-1.420)	
REGQUAL						-0.010* (-1.666)
HDI			0.036 (1.272)			
HDI educ				0.059** (2.445)		
HDI gdp				-0.112*** (-3.606)		
HDI lifeexp				0.077*** (3.776)		
SIZE	7.35E-09*** (4.640)	8.09E-09*** (4.741)	6.94E-09*** (4.199)	7.22E-09*** (4.131)	7.72E-09*** (5.037)	7.46E-09*** (4.732)
ISLAND	0.047*** (3.152)	0.053*** (3.528)	0.043*** (2.677)	0.042*** (2.694)	0.054*** (3.771)	0.050*** (3.487)
EQR	-0.0002 (-0.661)	0.0003 (1.243)	-0.0004 (-1.134)	-0.0003 (-0.876)	0.0002 (0.541)	-4.31E-05 (-0.163)
POPDENS	1.03E-05** (2.354)	1.39E-05*** (2.780)	8.58E-06* (1.950)	9.86E-06** (2.238)	1.34E-05** (2.353)	1.08E-05** (2.360)
IUCN	0.0003 (0.758)	0.0004 (1.094)	0.0002 (0.516)	0.0002 (0.456)	0.0004 (1.022)	0.0004 (0.921)
R²adj	0.1464	0.1664	0.1493	0.1924	0.1540	0.1434
N	163	163	161	161	163	163

Dependent variable is the ratio of endangered bird species to all bird species.

Absolute t-values in parenthesis.

* Significant at the 90 percent level.

** Significant at the 95 percent level.

*** Significant at the 99 percent level.

The investigation of World Bank governance indicators again provides an ambivalent picture in two respects: first, when looking at the state of institutions and second when analysing their change. While some of the indicators are significant, others are not (we only show two results). Yet, all show a negative sign, which means that stabile institutions and a good governance structure counteract a loss of biodiversity. Especially control of corruption (CCORR) and a high quality of regulation (REGQUAL) seem to prevent the destruction of biodiversity.

Table 4: Ratio of Endangered Biodiversity and Institutional Chance

	I	II	III	IV	V	VI
CONST	0.052*** (4.873)	0.049*** (4.446)	0.049*** (4.808)	0.043*** (4.136)	0.047*** (4.717)	0.048*** (4.766)
ΔGDP 80-05	-1.75E-06 (-0.207)	-2.85E-06 (-0.527)	-1.95E-06 (-0.339)	-2.07E-06 (-0.358)	2.55E-06 (0.328)	-2.51E-06 (-0.462)
ΔCCORR	-0.006 (-0.763)					
ΔGOVEFF		-0.015* (-1.669)				
ΔPOLSTAB			-0.012 (-0.281)			
ΔREGQUAL				-0.017*** (-2.933)		
ΔLAW					0.010 (1.012)	
ΔVOICE						-0.005 (-0.520)
SIZE	6.62E-09*** (3.964)	7.11E-09*** (4.558)	7.18E-09*** (4.467)	7.41E-09*** (4.987)	6.84E-09*** (4.201)	7.43E-09*** (4.597)
ISLAND	0.057*** (2.655)	0.057*** (3.618)	0.053*** (3.214)	0.055*** (3.655)	0.061*** (3.130)	0.049*** (3.227)
EQR	-2.95E-05 (1.237)	-1.77E-04 (-0.700)	-1.76E-04 (-0.748)	2.44E-05 (0.099)	-2.06E-04 (-0.883)	-1.52E-04 (-0.640)
POPDENS	1.13E-05*** (2.858)	1.10E-05*** (2.861)	1.01E-05** (2.330)	1.13E-05** (2.590)	1.16E-05*** (2.979)	1.06E-05** (2.415)
IUCN	0.0003 (0.668)	0.0002 (0.561)	0.0003 (0.681)	0.0002 (0.445)	0.0002 (0.622)	0.0003 (0.668)
R²adj	0.1833	0.1869	0.1675	0.1854	0.1994	0.1516
N	133	160	157	161	148	162

Dependent variable is the ratio of endangered bird species to all bird species.

Absolute t-values in parenthesis.

* Significant at the 90 percent level.

** Significant at the 95 percent level.

*** Significant at the 99 percent level.

To understand the dynamics of this effect, we run the same regressions with the rates of change of the respective governance indicators. As the World Bank only started measuring the institutions in 1996, we use the change in governance quality from 1996 till 2005. The results are displayed in table 4. While, different to the absolute values GOVEFF is significant and CCORR is not, REGQUAL shows still the same positive effect to prevent the endangerment of bird species. This result gives the hint that an adequate and efficient regulation of environment goods is required for a *sustainable* economic and ecological development.

However, as the IUCN variable in table 4 is no longer significant, this implies that property rights are either not relevant or incorporated in institutions. In the latter case, one can conclude that an assignment of the property rights on biodiversity to avoid the common property problem.

5. Conclusion

If one considers the weaknesses of the analysis (no time series, difficulties to measure biodiversity), one may still conclude in sum from our empirical results that economic growth is indeed harmful for biodiversity. This is in line with the first part of BKC. However, the existence of good institutions (especially a high quality of regulation) can in part prevent this effect, which can be cautiously interpreted as a hint that economic growth is not necessarily related to losses of biodiversity. With good institutions, these losses may be prevented or mitigated.

Having said this, we have to admit that according to our results, the recovery of biodiversity with increasing income was difficult to show. For the policymakers in developing countries, this implies that much more knowledge is needed to understand the interrelation between economic incentives, growth and biodiversity. Nevertheless, if considering our results also in case of biodiversity conservation a sustainable economic development is possible as it has been shown for environmental degradation via EKC. However, the precondition for this development is the existence of good institutions and out of it the assignment of property rights on biodiversity.

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Appendix A: Correlation Matrix

	BIRDS	BIRDS/ SIZE	EN BIRDS	GDP 2005	Δ GDP 80-05	HDI	HDI educ	HDI gdp	HDI lifexp	SIZE	ISLAN D	EQR	POP DENS	IUCN	CCOR R	GOVEF F	POLST AB	REG QUAL	LAW	VOICE	Δ CC ORR	Δ GOV EFF	Δ POL STAB	Δ REG QUAL	Δ LAW	Δ VOI CE
BIRDS	1,000																									
BIRDS/SIZE	-0,159	1,000																								
ENBIRDS	0,100	0,061	1,000																							
GDP 2005	-0,357	0,184	-0,21	1,000																						
Δ GDP 80-05	0,056	0,083	0,064	0,242	1,000																					
HDI	-0,271	0,161	0,165	0,736	-0,042	1,000																				
HDI educ	-0,161	0,083	0,167	0,581	-0,060	0,903	1,000																			
HDI gdp	-0,323	0,192	0,083	0,864	0,089	0,922	0,752	1,000																		
HDI lifexp	-0,255	0,165	0,202	0,575	-0,142	0,919	0,735	0,778	1,000																	
SIZE	0,402	-0,101	0,177	0,103	0,088	0,099	0,084	0,107	0,082	1,000																
ISLAND	-0,229	0,193	0,371	0,210	-0,036	0,216	0,163	0,230	0,199	-0,062	1,000															
EQR	-0,552	-0,057	-0,104	0,544	-0,211	0,635	0,580	0,581	0,579	0,032	0,039	1,000														
POP DENS	-0,131	0,669	0,165	0,199	0,106	0,164	0,079	0,190	0,179	-0,089	0,018	-0,086	1,000													
IUCN	0,356	0,028	0,069	0,042	0,051	0,048	0,104	0,034	-0,001	0,003	-0,024	-0,190	0,016	1,000												
CCORR	-0,396	0,221	0,070	0,815	-0,085	0,744	0,567	0,828	0,643	0,061	0,247	0,591	0,239	0,056	1,000											
GOVEFF	-0,360	0,214	0,126	0,807	-0,049	0,780	0,622	0,847	0,670	0,091	0,248	0,606	0,244	0,054	0,968	1,000										
POLST	-0,423	0,222	0,050	0,659	0,017	0,592	0,485	0,678	0,463	-0,012	0,174	0,485	0,176	-0,050	0,789	0,798	1,000									
REGQUAL	-0,346	0,237	0,092	0,761	-0,076	0,757	0,597	0,817	0,661	0,052	0,248	0,559	0,253	0,073	0,928	0,958	0,771	1,000								
LAW	-0,425	0,241	0,101	0,810	-0,044	0,754	0,575	0,828	0,666	0,057	0,259	0,603	0,234	0,038	0,975	0,969	0,821	0,937	1,000							
VOICE	-0,236	0,099	0,074	0,662	-0,183	0,652	0,547	0,696	0,546	0,040	0,266	0,546	0,069	0,097	0,839	0,869	0,739	0,883	0,833	1,000						
Δ CCORR	-0,136	0,110	-0,073	0,121	-0,111	0,194	0,181	0,184	0,168	-0,090	-0,004	0,145	0,029	0,053	0,248	0,218	0,285	0,236	0,240	0,149	1,000					
Δ GOVEFF	-0,183	0,173	-0,014	0,014	-0,002	0,128	0,148	0,117	0,088	-0,028	0,118	0,132	0,056	-0,019	0,135	0,207	0,346	0,223	0,161	0,212	0,477	1,000				
Δ POLSTAB	-0,070	0,075	-0,012	0,061	0,028	0,025	0,011	0,079	-0,020	0,011	-0,017	0,017	0,107	-0,072	0,079	0,092	0,333	0,091	0,098	0,081	0,322	0,419	1,000			
Δ REGQUAL	-0,432	0,094	-0,071	0,401	-0,064	0,311	0,224	0,357	0,271	0,035	0,104	0,458	0,064	-0,137	0,462	0,476	0,431	0,467	0,480	0,341	0,293	0,370	0,228	1,000		
Δ LAW	-0,288	0,259	-0,098	0,079	0,020	-0,033	-0,075	0,007	-0,024	-0,077	0,127	0,059	0,121	-0,136	0,147	0,128	0,282	0,118	0,178	0,024	0,536	0,471	0,447	0,341	1,000	
Δ VOICE	-0,088	0,077	0,020	0,287	0,025	0,251	0,158	0,278	0,253	0,099	0,021	0,230	0,112	-0,080	0,314	0,346	0,260	0,360	0,323	0,268	0,319	0,232	0,398	0,416	0,299	1,000

Appendix B: Countries included in the Analysis

Afghanistan	Dominica	Libya	Saint Vincent and the Grenadines
Albania	Dominican Rep.	Liechtenstein	Samoa
Algeria	Ecuador	Lithuania	San Marino
American Samoa	Egypt	Luxembourg	Sao Tome and Principe
Andorra	El Salvador	Macao	Saudi Arabia
Angola	Equatorial Guinea	Macedonia, FYR	Senegal
Antigua and Barbuda	Eritrea	Madagascar	Seychelles
Argentina	Estonia	Malawi	Sierra Leone
Armenia	Ethiopia	Malaysia	Singapore
Aruba	Fiji	Maldives	Slovakia
Australia	Finland	Mali	Slovenia
Austria	France	Malta	Solomon Islands
Azerbaijan	French Polynesia	Marshall Islands	Somalia
Bahamas	Gabon	Mauritania	South Africa
Bahrain	Gambia	Mauritius	Spain
Bangladesh	Georgia	Mayotte	Sri Lanka
Barbados	Germany	Mexico	Sudan
Belarus	Ghana	Micronesia	Suriname
Belgium	Greece	Moldova	Swaziland
Belize	Grenada	Monaco	Sweden
Benin	Guam	Mongolia	Switzerland
Bermuda	Guatemala	Morocco	Syria
Bhutan	Guinea	Mozambique	Taiwan
Bolivia	Guinea-Bissau	Myanmar	Tajikistan
Bosnia and Herzegovina	Guyana	Northern Marianals	Tanzania
Botswana	Haiti	Namibia	Thailand
Brazil	Honduras	Nepal	Togo
Brunei	Hong Kong	Neth. Antilles	Tonga
Bulgaria	Hungary	Netherlands	Trinidad and Tobago
Burkina Faso	Iceland	New Zealand	Tunisia
Burundi	India	New Caledonia	Turkey
Cambodia	Indonesia	Nicaragua	Turkmenistan
Cameroon	Iran, Islamic Rep.	Niger	Uganda
Canada	Iraq	Nigeria	Ukraine
Cape Verde	Ireland	Norway	United Arab Emirates
Cayman Islands	Israel	Oman	United Kingdom
Central African Rep.	Italy	Pakistan	United States
Chad	Jamaica	Palau	Uruguay
Chile	Japan	Panama	Uzbekistan
China	Jordan	Papua New Guinea	Vanuatu
Colombia	Kazakhstan	Paraguay	Venezuela
Comoros	Kenya	Peru	Vietnam
Congo, Dem. R.	Kiribati	Philippines	Virgin Island
Congo, Rep. of	Korea, DPRp	Poland	Yemen
Costa Rica	Korea, Republic of	Portugal	Zambia
Cote d'Ivoire	Kuwait	Puerto Rico	Zimbabwe
Croatia	Kyrgyzstan	Qatar	
Cuba	Laos	Romania	
Cyprus	Latvia	Russian Federation	
Czech Republic	Lebanon	Rwanda	
Denmark	Lesotho	Saint Kitts and Nevis	
Djibouti	Liberia	Saint Lucia	