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Student Name: Svetoslav Milushev
Student ID Number: 616531
Supervisor: dr. S.V. Kapoor
Second assessor: dr. J. Emami Namini
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"How effective are economic sanctions? A Night Time Lights Analysis of Sanction Regimes in the post-Cold War world."

Svetoslav Milushev

Abstract

The recent Russian invasion of Ukraine and the subsequent response of western countries have brought economic sanctions to the center of foreign policy discussions both for governments and the general public. Sanctions are meant to cause harm to a country's economy, forcing its government to comply with demands or risk an economic crisis and potential civil unrest, with sanctions being viewed as a better alternative to military interventions. But just how effective are sanctions at causing economic harm? This paper intends to answer this question by examining the effects of UN and US sanctions for the period 1993-2013 on the economic development of sanctioned of 158 countries using Night Time Lights (NTL) data as a proxy for economic activity. I find a reduction in GDP growth of 1.1% and a 1.9% reduction in NTL growth for US sanctions as a whole, but the study cannot make definitive conclusions regarding the effects of UN sanctions, largely due to the low number of cases.

Contents

1. Introduction

By June 2022, or about 3 months after the invasion of Ukraine, Russia has been the target of a wide range of sanctions on a level not seen since the Iraqi invasion of Kuwait or the Yugoslav wars. A key difference between these conflicts and this one is that Russia is a permanent member of the UN Security Council and, more importantly, is a nuclear power. With direct military intervention being ruled out on account of mutually assured destruction, western powers are left with two paths of influencing the outcome of this conflict. One is by providing the government of Ukraine with military and financial aid. The other is by levying sanctions against key Russian political circles and industrial sectors, aiming to cause a row in Putin's support base and hinder Russia's ability to wage war over a protracted period of time.

While certainly not new, the sheer scale of sanctions employed against Russia after its invasion of Ukraine has pushed sanctions into the public spotlight. Given the important role sanctions are to play in the crisis, the question has been raised over how effective are sanctions in achieving their goals. The literature appears inconclusive (van Bergeijk, 2019), with varying definitions of success and effectiveness giving different percentages of success rates (Peksen 2019). In light of this, this study aims to take a step back and re-examine the main mechanism through which, at least in theory, sanctions coerce their targets into compliance, namely economic damage, using both traditional indicators such as GDP and introducing new measures like Nighttime lights.

Findings suggest that US trade sanctions, such as restrictions on imports and exports, reduce GDP growth by around 2.4% per year. That said, trade sanctions lose their significance when examining NTL, which could indicate grey and black sectors increasing in response to sanctions. This would imply that sanctions may be less impactful than what official indicators would point to. US sanctions do, however, remain significant as a whole, leading to a 1.1% reduction in annual GDP growth and 1.9% reduction in NTL, suggesting comprehensive sanctions remain an effective tool. UN sanctions, on the other hand, remain insignificant at aggregated levels. Disaggregating them by type leads to statistically significant effect on GDP for arms, travel and others categories of sanctions, but these estimates are not robust to different sets of controls. UN arms sanctions do remain significant for NTL, but the size of the effect varies across specifications from 6.6% to 11%.

This paper fits into both literature on sanctions and Nighttime lights. On the one hand, it contributes to the sanctions literature by using the new Global Sanctions Database and applying a quantitative approach to study the impact of sanctions. This paper does not intend to weigh in on the debate whether sanctions are necessarily effective or successful, but rather aims to gauge the effect of sanctions on the target country. On the other hand, it tests how well Nighttime Lights fit in as a proxy for economic development vis-à-vis more traditional indicators such as GDP per capita and highlights potential benefits and drawback from using it as such.

2. Literature Review

Sanctions

Existing literature on sanctions has mostly focused on the success rate of sanctions as a foreign policy tool, primarily using case study analysis of specific sanction episodes as the unit of analysis. From this perspective, effectiveness has often meant the ability of sanctions to get the target to fully or partially comply with the demands of the sanctioning countries. The main mechanism through which this is achieved is through reduced trade, leading to a slowdown of the economy and making the target government incur economic costs. This basic economic model has remained for the most part unchanged since it was first introduced in the late 60s (Galtung, 1967). In his meta-analysis, Dursun Peksen (2019) identifies two strands regarding the role of economic costs on the effectiveness of sanctions. One strand, dubbed the "naïve theory of sanctions", posits that large and up-front economic costs can damage a leader's legitimacy and undermine his coercive capacity, forcing him to compromise, lest he/she risks being ousted from power (Galtung 1967). Evidence in support of this theory have been found by more recent scholars (Dashti-Gibson *et al* 1997; Hufbauer *et al* 2007; Bapat *et al* 2013;), emphasizing the role of imposing large costs early on, rather than increasing them over time (Hufbauer *et al* 2007, Dizaji and van Bergeijk 2013;).

The second strand, while also recognizing the importance of major costs on the target, notes that targeting sanctions against specific individuals or groups may be more effective in achieving the stated objectives. This line of reasoning can be traced to Kaempfer and Lowenberg's public choice approach on sanctions (1988). Their model identifies two groups, those that benefit from sanctions and those that lose from them, with the outcome of sanctions being dependent on which group is better at exercising political power. As such, targeting small, but politically influential group may bring about the desired political

outcome at a much lower cost to the sanctioning country. This public choice model, along with concerns regarding negative externalities of broad sanctions, has contributed to the recent shift from broad sanctions focused on trade embargoes, to more focused, targeted sanctions using financial instruments and restrictions.

On the quantitative side, analyses on the effectiveness of sanctions and the mechanisms through which they influence their targets are relatively few, partly due to the lack of comprehensive databases on sanctions. The first sanctions database was compiled by Gary Hufbauer *et al* 1990, last updated in 2009 and includes 174 sanction cases from 1914 to 2006, sometimes referred to as the HSEO database, reporting a sanction success rate of 34%. More recent databases include the Threat and Imposition of Sanction (TIES) database (Morgan *et* al 2014) and the UN Targeted Sanctions database (Biersteker *et al* 2018). These databases, while detailed in terms of success rate, motivation and stated objectives, are compiled as individual sanction episodes instead of panel data, making it more difficult to apply time-series analysis and econometric techniques. Nonetheless, this has not stopped researchers from using them in their empirical studies. (Dashti-Gibson *et al* 1997;Wood 2008; Peksen 2010).

The development of two new sanctions databases may prompt more detailed research into the economic effect of sanctions. The EUSANCT database, developed by Weber and Schneider and published in 2020, compiles sanction episodes from 1989 to 2015, focusing on the US, UN and EU as senders of sanctions and encompassing 326 threatened and imposed sanction cases. The database provides both case level and dyadic information, allowing for both qualitative and quantitative analysis and includes a variety of political indicators and variables. Published in the same year was the Global Sanctions Database (GSDB), develop by Felbermayr *et al*. The database contains 1101 sanctions cases spanning the period from 1950 to 2019, being one of the largest databases to date, while also presenting its data in both case level and dyadic form. These two databases are likely to make it easier to apply quantitative analysis to the sanctions literature.

Still, research on how sanctions affect economic indicators is relatively scarce. Neuenkirch and Neumeier (2015) use a fixed effects regression to study the effects of sanctions on GDP using the HSEO database[1] as a foundation, finding high statistical significance for both US

[1] The researchers use an existing extension of the database used by Wood (2008) and further update it manually until 2012.

and UN sanctions. Shin *et al* (2016) use panel corrected standard errors to gauge the effect of sanction on terms of trade, net FDI flows and foreign portfolio investment using the TIES database. Their research fails to find statistical significance, regardless of sender and severity, suggesting the profit-seeking nature international businesses and corporations as the reason.

One potential downside of these studies is that they focus on formal economic indicators. As highlighted by Early and Peksen (2019), sanctions can also have an effect on a country's grey or illegal sectors. Using a country fixed effects model, the researcher find a statistically significant positive effect of sanctions on the size of a country's shadow economy as a percentage of GDP. This highlights potential issues with using official statistics to gauge the impact of sanctions. While shadow economies do reduce government revenue, they still provide goods and services that may otherwise be impossible under sanctions, reducing their potential impact in a way that is difficult to measure.

Nighttime lights

In light of these concerns, this study will also analyze the effect of sanctions on Nighttime Lights. The link between human activity and nighttime lights had been made as early as 1978 (Croft, 1978), but it wasn't until 1992 that digital data from the US Defense Meteorological Satellite Program (DMSP) began to be compiled by the National Oceanic and Atmospheric Administration and more studies began using it. The early NTL literature has mostly been used to examine sub-national economic development and augment existing estimations of GDP (Elvidge et al 1997, Sutton *et* al 2007, Ghosh et al 2010;). NTL has also been used to estimate the size of non-marketed ecosystems and the informal sector. Ghosh et al 2009 use DMSP data to estimate the non-formal sector in Mexico, using the US as a calibration baseline. Chen and Nordhaus (2011) and Henderson *et al* (2012) were the first to employ a time-series analysis of GDP and NTL growth using fixed effects models. Henderson *et* al find a statistically significant link between growth in Nighttime Lights and GDP growth. Despite rejecting linearity of their overall sample (177 countries over 17 years) after a RESET test, they nonetheless suggest a linear relationship after finding no significant higher order polynomials. While also finding a similar link, Chen and Nordhaus note that nighttime lights are best used as proxies for countries with low statistical capacity, as the national accounts of more developed countries usually have less measurement error than NTL data.

3. Methodology and Data

Model

The goal of this study is to quantify the effect of sanctions on economic activity and determine their ability to cause said economic damage. This will be done through a fixed-effects regression using GDP growth and Nighttime lights growth as indicators of economic activity, using data from 1993 to 2013 from 158 countries[2]. Specifically, this paper will examine the effect of US and UN sanctions while differentiating between different levels of severity and type. Due to the nature of the research question, a fixed effects regression will be employed in order to account for country and time fixed effects, which may otherwise bias the data. Country fixed effects are derived by taking the regression estimates and subtracting from them the mean estimate for that country. By doing this, any factors that are time-invariant and specific to that country (e.g. country size, terrain, climate, culture) are differenced out. Time fixed effects are implemented by introducing time dummies for each year in the regression, capturing global trends and events which would influence all countries. Such factors could include global recessions, technological changes and others. Given that the time period examined includes the Great Recession and the wide range of countries included in the analysis, a fixed effects model is necessary to prevent bias in the data. The formal model is defined below,

$$\gamma_{i,t} = \alpha_i + \beta_1 sanctions_{i,t} + X_{i,t}\beta + \delta_{i,t} + \varepsilon_{i,t}$$

where $\gamma_{i,t}$ indicates annual growth for real GDP per capita or NTL for country *i* at time *t* compared to previous year, β_1 stands for dummy variable indicating sanctions, their severity or type, α_i and δ_t stand for country and time fixed effects respectively; $X_{i,t}$ indicates the control variables and $\varepsilon_{i,t}$ is the error term.

The regression will be run in log-log form in order to facilitate easier interpretation of the results. This is motivated by a specificity of the NTL data, namely that it is recorded as Digital Numbers (DN). This measurement unit is not immediately relatable to traditional luminosity measurements and is a limitation of the older DMSP OLS satellites. Another motivations lies with what nighttime lights pick up, namely stable light sources such as street-lamps, housing buildings and other static sources which may have been built years

[2] A list of countries included is provided in the Appendix, Table A1.

before sanctions were imposed. Growth rates, on the other hand, are able to capture new investments and would be able to account for changes induced by the implementation of a sanctions regime. As such, NTL growth is employed in order to better gauge changes induced by sanctions. The use of GDP growth rates, on the other hand, is motivated by the difficulty of inter-country comparisons of GDP. The use of Purchasing Power Parity is not perfect and sometimes comparisons may be misleading or outright impossible (Deaton and Heston, 2010). While not a perfect solution, the use of GDP growth rates nonetheless makes it easier to gauge the effects of sanctions between countries as different as France and Bangladesh.

Data

The primary data source for this paper is the Global Sanctions Database developed by Felbermayr *et al* (2020). The database contains over a thousand multi- and bi-lateral sanction cases from 1950 to 2019. The database differentiates between several types of sanctions through dummy variables and its dyadic structure allows for easier implementation of a time series analysis. I have transformed these different types of sanctions into three different severity levels for both US and UN sanctions using the typology used by Neuenkirch *et al*, outlined in Table 1.

GDP data and growth rates were sourced from the UN Statistical Division's National Accounts. Population lag and a lag on GDP growth are used as controls in order to isolate the effects on GDP growth. Trade as a percentage of GDP data is also used as a control, as economies that rely more heavily on trade may be more vulnerable to sanctions and foreign pressure. Unfortunately, trade data is not available for all observations, with Afghanistan, Liberia, Malawi, Liberia and Triniad and Tobago missing entirely. The effects of changing the sample size with additional controls is tested in the Sensitivity and Robustness section. Both population and trade data are taken from the World Development Indicators by the World Bank

Controls

Common controls in the sanctions literature also include indicators for the type of government (democratic or autocratic) and levels of state terror. It is believed that autocracies and states with high levels of repression are better able to weather incoming sanction through a quicker and more centralized response with the ability to contain discontent and local unrest. Indicators for type of government (democratic vs autocratic) were drawn from the

Table 1

Sanction severity definitions and the corresponding dummies from GSDB

Level	UN sanctions	US sanctions	GSDB dummies
1. Mild	Restrictions on arms and other military hardware; typically include travel restrictions on a nation's leadership or other diplomatic sanctions as well	Retractions of foreign aid, bans on grants, loans, or credits, or restrictions on the sale of specific products or technologies; not including primary commodities embargoes	All sanctions including arms, military, travel or other restrictions and not including a higher severity measure
2. Moderate	Fuel embargoes, restrictions on trade in primary commodities, or the freezing of public and/or private assets	Import or export restrictions, bans on US investment, and other moderate restrictions on trade, finance, and investment between the US and target nation	Sanctions including financial or trade sanctions, with only partial embargoes being included and containing no higher severity
3. Severe	Comprehensive economic sanctions such as embargoes on all or most economic activity between UN member states and the target	Comprehensive economic sanctions such as embargoes on all or most economic activity between the US and the target nation	Only includes trade sanctions containing a full embargo on imports, exports or both

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Polity V Regime Authority Characteristics and Transitions Dataset, with the indicator being normalized from a -10 to +10 scale into a 0 to 20 scale in order to facilitate easier interpretation. Unfortunately, variables for Bosnia, Afghanistan, Iraq and Lebanon are missing during some periods of sanction, with Afghanistan and Iraq being particularly important for the relatively small sample of UN sanction episodes. The Polity database classifies these cases as "Interruption periods" in which the polity is temporarily terminated, often the result of a war. In order to facilitate the regression while keeping Polity V as a control, those missing variables are set to 10 (or 0 before the adjustment), the middle of the scale. This is the same method the database uses to code interregnum periods, which in older versions were always counted as missing. The effects of this change is reflected in the sensitivity and robustness sections.

Information on state terror was taken from the Political Terror Scale dataset. The dataset contains individual variables based on Human Rights Watch, Amnesty International and US State department assessments. The variable used in the regression is an average of the available assessments, as not all countries have all three.

Nighttime lights data

Nighttime Lights data was sourced using information from the DMSP satellites, while using Google Earth Engine to aggregate average light across countries. The satellites use Operational Linescan Systems (OLS) to collect low level light, among other meteorological data. The resulting images are then processed by the NOAA, cleaning the data from stray lunar lights, auroral activity, and removing images with too-much cloud cover. The final product is then published and is the one used by the study, specifically the "stable_lights" band which contains lights only from persistent light sources, such as cities and towns and gas flares from oil rigs. A more modern satellite system was launched in 2012, containing advanced technology and sensors. While more detailed, the new monthly VIIRS satellite images are not yet filtered for aurora, fires and other temporal light and offer few years of observation. An early attempt made to combine DMSP and VIIRS data yielded a sharp discontinuity around the point where the new data was added and harmonizing the data is beyond the scope of this study. Therefore, in an effort to maintain uniformity of the data, DMSP data was the one used in this paper.

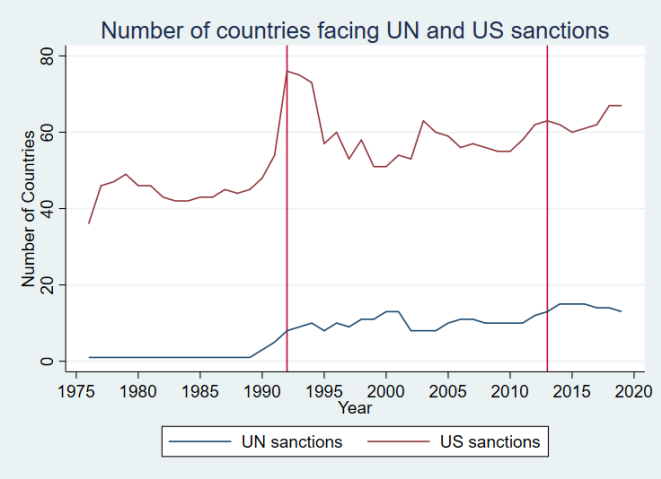
A potential issue with NTL data is top-coding. There is a cap on the maximum radiance the satellites can capture (63), which could lead to underestimation of radiance from large and

well-developed cities. A radiance-calibrated version is available, allowing for a much higher cap (175), but it is only calculated for a few given years. As such, the choice was made to use the standard DMSP Nighttime Light v.4 as the basis for Nighttime lights in this study.

Another potential weakness of NTL and DMSP OLS is that it is has high variance across observations. Running a regression with a lagged growth rate for nighttime lights shows a highly significant and negative sign. These variances are largely attributed to the older technology used by DMSP OLS satellites in capturing these images and is believed to be at random. Potential biases between different types of satellites can be controlled for through year fixed effects, as at most two satellites are in orbit at any time. As such, under the assumption of a zero-mean standard error, conclusions may still be drawn from the data. Another specificity of the NTL data is the unit of measurement.

Time frame and sanctions composition

The choice of NTL data also motivates the choice of the time period. Public data on NTL from the DMSP OLS program span the period from 1992 to 2013, covering around 21 years of nighttime lights growth. While shorter than the period covered by other empirical studies, it benefits from the fact that it takes place after the end of the Cold War and the subsequent wave of new independent states out of the former Soviet bloc, lowering the need to rely on estimations and approximations for older values. Graph 1 shows a list of total sanctions from 1976 to 2019, with the vertical lines indicating the period covered by NTL data. It should be noted that the graph does not include sanctions related to the American Service-Members Protection Act signed by the Bush administration and lasting from 2002 to 2008. The Act introduced restrictions on military cooperation with all signatories of the Rome Statute of the International Criminal Court. The restrictions in question are specifically a refusal to co-operate with ICC requests for investigation of American staff and military service personnel and, while technically a military restriction, shouldn't have a causal effect on GDP or NTL. As such this sanctions case is treated as an outlier case and by default not included in summary statistics. Graphs including ASPA related sanctions can be seen in the Appendix. As can be seen form Graph 1, the majority of UN sanctions started after the end of the Cold War while US sanctions also experienced a growth of target countries. The first major increase is related to the breakup of Yugoslavia and the subsequent Yugoslav wars, seeing both UN and US sanctions increase.

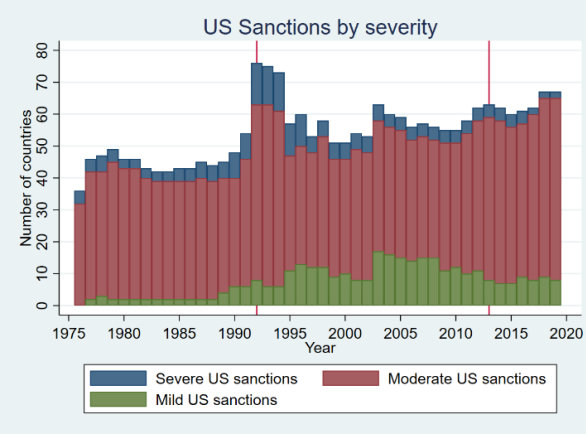


Graph 1

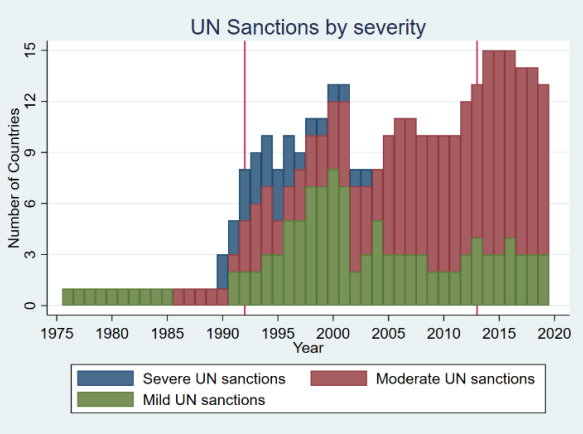
The list of countries used was based on the one employed by Neuenkirch and Neumeier and contains 158 countries. For the period examined, 23 countries were subject to UN sanctions and 70 were sanctioned by the US. A breakdown of the number of sanctions by their severity is presented in Graphs 2 and 3[3]. The US seems to maintain a fairly consistent and slightly increasing number of active sanctions over time, with a notable rise in the early 1990s, likely a result of the Yugoslav conflict. The reference lines represent the period covered by DMSP data. The period also covers most of the UN sanction cases, although the beginning of the Yugoslav wars is cut off. The GSDB also separately tracks different types of sanctions, namely arms embargoes, military and travel restrictions, trade and financial sanctions and an others category, with the formal definitions summed up in Table 2.

Graphs 4 and 5 further disaggregate sanctions by their type for US and UN sanctions respectively. All types of US sanctions pick up for around the early 1990s and remain at a higher level after the end of the Yugoslav wars, suggesting a general shift taking place after the end of the Cold War. A second shift can be observed around 2002, as the US reacts to the 9-11 terrorist attack. Military sanctions increase, yet arms restrictions seem to be reduced. The end of the Bush administration seems to bring down military sanctions. Throughout the period, financial sanctions remain the most common measure employed by the US government, with the number of countries targeted steadily increasing after 2010. On the other hand, UN sanctions in the 1990s primarily consist of arms, military and trade related

[3] A graph with ASPA included is available in the Appendix



Graph 2

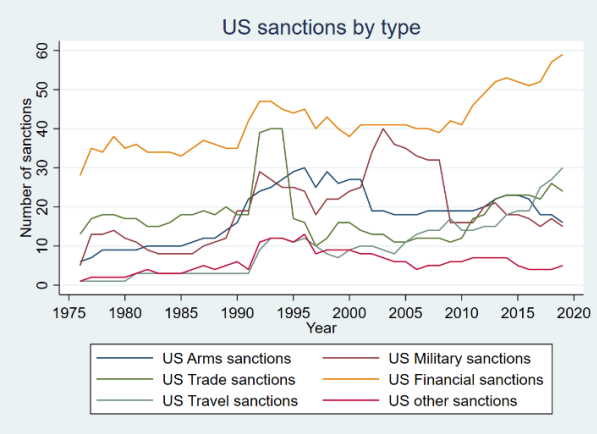


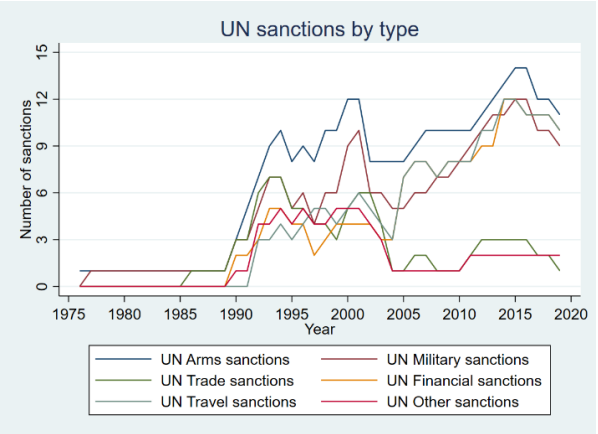
Graph 3

Table 2

Types of sanctions and their definitions by the Global Sanctions Database

Type of sanction	GSDB definition
Arms	Restrictions on arms sales, both from and to the target.
Military	Ban of military assistance, either monetary or personal.
Trade	Measures that aim to restrain economic interaction with a target country by limiting international trade. Differentiates between import/export and partial/complete embargoes.
Financial	Involves freezing the exchange of financial assets and investments. Can restrict direct investment and/or limit the availability of credit in exchange of commodities including aid payments.
Travel	Restrictions of the freedom of geographical movement of individuals.
Other	Residual category, primarily diplomatic measures.





Graph 4 ***Graph 5***

sanctions, with military and arms sanctions spiking around the new millennium. After 2005, trade restrictions lose popularity, while all other UN sanction types begin steadily increasing.

4. Results

Aggregate Sanctions effect

Table 3 shows the results when running the model without any controls. Both UN and US sanctions are insignificant when it comes to GDP, but UN sanctions are significant for NTL,

Table 3

No controls FE regression

	(1)	(2)	(3)	(4)
	%GDP growth	%NTL growth	%GDP growth	%NTL growth
US sanctions	-0.0074	-0.0067	-0.0117*	-0.0185**
	(0.0045)	(0.0061)	(0.0062)	(0.0074)
UN sanctions	0.0010	-0.0335*	0.0029	-0.0284
	(0.0117)	(0.0195)	(0.0119)	(0.0191)
ASPA			0.0096	0.0263**
			(0.0071)	(0.0108)
Observations	3318	3318	3318	3318
R-squared	0.0630	0.4687	0.0639	0.4693

Notes: Dependent variables are annual GDP growth rates in 2010 USD for Column 1 and 3. Dependent variables are annual average Nighttime light growth for Columns 2 and 4. The model includes country and year fixed effects. The model includes country and year fixed effects. Independent variables include US and UN sanctions dummies and sanctions related to the American Service-Members' Protection Act (ASPA). US sanctions become significant for NTL and weakly significant for GDDP after controlling for ASPA. Robust standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

albeit at a 90% confidence level. Controlling for the sanctions imposed after the ASPA act, the effect of US sanctions on GDP growth becomes significant at 90% and at 95% for NTL. UN sanctions, on the other hand, lose their NTL significance level and remain insignificant for both categories. Given that there are no observations with both ASPA and UN sanctions at the same time, it is unlikely that the correlation was causal.

The second set of regressions shown in Table 4 employ the full list of controls, with a separate regression set being run without including the trade indicator. The reason behind this is that, as mentioned in the data section, not all countries have information for trade

Table 4

Controls FE regression

	(1)	(2)	(3)	(4)
	%GDP growth	%NTL growth	%GDP growth	%NTL growth
US sanctions	-0.0062	-0.0173**	-0.0106**	-0.0190**
	(0.0055)	(0.0075)	(0.0050)	(0.0077)
UN sanctions	0.0099	-0.0183	0.0106	-0.0265
	(0.0093)	(0.0199)	(0.0110)	(0.0209)
Lagged GDP growth	0.2189***		0.1752*	
	(0.0740)		(0.0947)	
Lagged pop. growth	-0.1392	0.5323	-0.3186	0.4993
	(0.2975)	(0.3697)	(0.2702)	(0.3824)
ASPA	0.0067	0.0287***	0.0092*	0.0314***
	(0.0054)	(0.0109)	(0.0052)	(0.0109)
PTS	-0.0115***	-0.0151*	-0.0088**	-0.0138*
	(0.0036)	(0.0079)	(0.0036)	(0.0075)
Adj. Polity	-0.0003	-0.0013	-0.0002	-0.0011
	(0.0006)	(0.0012)	(0.0006)	(0.0012)
Trade %GDP			-0.0000	0.0002
			(0.0001)	(0.0002)
Observations	3313	3313	3022	3022
R-squared	0.1299	0.4718	0.1061	0.4924

Notes: Dependent variables are annual GDP growth rates in 2010 USD for Column 1 and 3. Dependent variables are annual average Nighttime light growth for Columns 2 and 4. The model includes country and year fixed effects. Independent variables include US and UN sanctions dummies. Controls also include sanctions related to the American Service-Members' Protection Act (ASPA), lagged GDP growth, lagged population growth, Political Terror Scale indicator, Trade as a percentage of GDP and an adjusted Polity indicator (0 indicating strongly autocratic, 20 indicating strongly democratic; missing values set to 10). US sanctions are significant for NTL growth and become significant for GDP when Trade as a percent of GDP is included as a control variable.

Robust standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

percentages. Many countries have large periods with missing variables and information is completely lacking for Trinidad and Tobago, Malawi, Liberia and Afghanistan, the last two being the target of both US and UN sanctions for a long period. The inclusion of trade makes US sanctions significant at 95%, indicating a 1.06% reduction in GDP growth, with the effect remaining around a 1.9% reduction, significant both with and without trade as a control.

Sanctions effect by severity

Table 5 shows the results when sanctions are differentiated by severity. Columns 1 and 2 represent the results of breaking down US sanctions while keeping UN sanctions together. Only moderate sanctions, those including financial and trade restrictions, are significant, leading to a reduction of 1.46% of GDP growth. This is likely due to the effect of this type of sanction on net exports, which would be reflected directly in GDP. Moderate sanctions are also significant for Nighttime lights, leading to a reduction of 1.72% in NTL growth rate. Under this specification, UN sanctions are all insignificant.

Columns 3 and 4 break-up UN sanctions by severity while leaving US sanctions together. All UN sanctions remain insignificant for both GDP and NTL, while US sanctions remain significant at 95% with a 1.05% and 1.9% reduction in GDP and NTL respectively, mirroring the results from the base specification. The final two columns show the regression results when both types of sanctions are added according to severity. Moderate US sanctions are still significant at 95%, while having their effect increased to 1.6% reduction in GDP and 1.86% for NTL. Severe UN sanctions become weakly significant at 90%, but all other UN sanctions remain insignificant.

Sanctions effect by type

Table 6 shows the results of the regression after taking advantage of the additional information provided by GSDB and distinguishing between different types of sanctions. Columns 1 and 2 show the results for GDP and NTL when breaking down US sanctions. Trade restrictions are significant for GDP, but insignificant for NTL and of the wrong sign. This could hint to an increase of grey and black market activities prompted by sanction regimes. UN sanctions remain insignificant for GDP, but gain weak significance for NTL at 90% confidence level. Columns 3 and 4 similarly compare the effects of different types of UN sanctions, while holding US sanction as a group. The results are somewhat surprising. US sanctions remain significant for both GDP and NTL, reducing them by 1.18% and 1.93% respectively. UN sanctions, on the other hand, show significant results for travel and “other”

Table 5

FE regression by severity

	(1) %GDP growth	(2) %NTL growth	(3) %GDP growth	(4) %NTL growth	(5) %GDP growth	(6) %NTL growth
US mild	-0.0018	-0.0241			0.0010	-0.0234
	(0.0069)	(0.0157)			(0.0064)	(0.0157)
US moderate	-0.0146**	-0.0172**			-0.0159**	-0.0186**
	(0.0064)	(0.0082)			(0.0064)	(0.0082)
US severe	0.0037	0.0386			0.0192	0.0715
	(0.0261)	(0.0516)			(0.0319)	(0.0600)
UN sanctions	0.0092	-0.0320				
	(0.0115)	(0.0210)				
UN mild			-0.0040	-0.0310	-0.0085	-0.0333
			(0.0173)	(0.0269)	(0.0178)	(0.0265)
UN moderate			0.0216	-0.0221	0.0215	-0.0309
			(0.0134)	(0.0207)	(0.0144)	(0.0214)
UN severe			-0.0145	-0.0546	-0.0505	-0.1479*
			(0.0145)	(0.0464)	(0.0386)	(0.0796)
US sanctions			-0.0105**	-0.0190**		
			(0.0050)	(0.0076)		
Lagged GDP growth	0.1710*		0.1780*		0.1736*	
	(0.0941)		(0.0950)		(0.0941)	
Lagged pop. growth	-0.3194	0.5193	-0.3055	0.5072	-0.2956	0.5504
	(0.2673)	(0.3782)	(0.2699)	(0.3872)	(0.2646)	(0.3786)
Trade %GDP	-0.0000	0.0002	-0.0000	0.0002	-0.0000	0.0002
	(0.0001)	(0.0002)	(0.0001)	(0.0002)	(0.0001)	(0.0002)
PTS	-0.0089**	-0.0141*	-0.0090**	-0.0139*	-0.0092***	-0.0145**
	(0.0035)	(0.0072)	(0.0037)	(0.0075)	(0.0035)	(0.0070)
Adj. Polity	-0.0001	-0.0008	-0.0003	-0.0013	-0.0003	-0.0012
	(0.0006)	(0.0012)	(0.0007)	(0.0012)	(0.0007)	(0.0012)
ASPA	0.0008	0.0354**	0.0095*	0.0318***	-0.0013	0.0352**
	(0.0078)	(0.0163)	(0.0053)	(0.0109)	(0.0073)	(0.0163)
Observations	3022	3022	3022	3022	3022	3022
R-squared	0.1081	0.4930	0.1083	0.4925	0.1124	0.4935

Notes: Dependent variables are annual GDP growth rates in 2010 USD for Column 1, 3 and 5. Dependent variables are annual average Nighttime light growth for Columns 2, 4 and 6. The model includes country and year fixed effects. Independent variables include US and UN sanctions dummies and separate dummies for their respective severity: mild (arms, military, travel and other sanctions), moderate (financial and trade sanctions) and severe (complete embargo on imports, exports or both). Controls also include sanctions related to the

American Service-Members' Protection Act (ASPA), lagged GDP growth, lagged population growth, Political Terror Scale indicator, Trade as a percentage of GDP and an adjusted Polity indicator (0 indicating strongly autocratic, 20 indicating strongly democratic; missing values set to 10). Only US moderate sanctions and US sanctions as a whole remain significant, suggesting diminishing returns of harsher sanctions.

Robust standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

categories, both showing a substantial change in GDP growth by 7.75%, but travel restrictions are of a positive sign, while others category shows a negative one. For NTL growth, arms, military and travel sanctions become weakly significant (with military and travel being positive), while the others category remains significant at 95% with a reduction of 7.46% in NTL growth. It should be noted that the R-squared term is much higher for NTL (0.49) than for GDP (0.11). While not indicative on its own, it is consistent across all tables in the study, and does suggest that NTL are a more robust estimator.

Columns 5 and 6 show the results when both US and UN sanctions are differentiated by type. For the US, trade sanctions remain significant, increasing their reduction to 2.42% of GDP, along with arms sanctions becoming weakly significant, but of the wrong sign. None of the sanctions achieve a significant effect on NTL growth, however. UN sanctions once again show significance for both travel and others categories, with travel retaining its positive sign and both types correlating a change of 7.8% in GDP growth. For Nighttime lights, travel sanctions become insignificant, while the others category becomes only weakly significant. Arms and military sanctions become significant at 95% for NTL. Arms restrictions seemingly cause an 11% reduction in NTL growth, while only showing a weakly significant effect on GDP. Military sanctions, meanwhile, imply a 7.3% increase in nighttime lights but otherwise remain insignificant when it comes to GDP. These puzzling results may be caused by the relatively fewer UN sanction cases, as breaking them down further leaves very few observations per type. Additionally, UN sanction types are almost never employed separately from one another, making it more difficult to disentangle their effects.

Lagged sanctions effect

Another dimension which could shift the effect of sanctions is time after sanctions are imposed. As such the fixed effects model has been run with lags included for aggregate sanctions and sanctions by severity as shown in Table 7. Column 1 and 2 show the regression for aggregate sanctions. US sanctions lose their significance when compared to the no lag baseline, with lagged US sanctions being weakly significant for GDP growth. UN sanctions

Table 6

FE regression by sanction type

	(1) %GDP growth	(2) %NTL growth	(3) %GDP growth	(4) %NTL growth	(5) %GDP growth	(6) %NTL growth
US arms	0.0062	0.0079			0.0120*	0.0077
	(0.0068)	(0.0149)			(0.0070)	(0.0140)
US military	0.0003	-0.0004			-0.0025	-0.0006
	(0.0058)	(0.0127)			(0.0058)	(0.0126)
US trade	-0.0199**	0.0193			-0.0242**	0.0204
	(0.0098)	(0.0174)			(0.0109)	(0.0181)
US financial	0.0030	-0.0214			0.0045	-0.0237
	(0.0081)	(0.0160)			(0.0085)	(0.0163)
US travel	0.0116	0.0353*			-0.0017	0.0379
	(0.0123)	(0.0201)			(0.0179)	(0.0239)
US other	-0.0099	-0.0204			-0.0031	-0.0121
	(0.0107)	(0.0179)			(0.0161)	(0.0234)
UN sanctions	0.0052	-0.0563*				
	(0.0161)	(0.0308)				
UN arms			-0.0513	-0.0910*	-0.0717*	-0.1103**
			(0.0334)	(0.0507)	(0.0381)	(0.0532)
UN military			0.0478	0.0650*	0.0598	0.0731**
			(0.0368)	(0.0379)	(0.0389)	(0.0365)
UN trade			0.0258	-0.0154	0.0403	-0.0250
			(0.0211)	(0.0186)	(0.0244)	(0.0185)
UN financial			-0.0402*	-0.0208	-0.0353	-0.0168
			(0.0235)	(0.0229)	(0.0265)	(0.0294)
UN travel			0.0775***	0.0549*	0.0783**	0.0226
			(0.0296)	(0.0302)	(0.0362)	(0.0353)
UN other			-0.0775**	-0.0746**	-0.0787**	-0.0670*
			(0.0333)	(0.0317)	(0.0393)	(0.0397)
US sanctions			-0.0118**	-0.0193**		
			(0.0052)	(0.0076)		
Lagged GDP growth	0.1715*		0.1677*		0.1614	
	(0.0940)		(0.0994)		(0.0992)	
Lagged pop. growth	-0.3437	0.4581	-0.3692	0.4559	-0.4014*	0.4171
	(0.2650)	(0.3710)	(0.2471)	(0.3551)	(0.2398)	(0.3370)
Trade %GDP	-0.0000	0.0002	-0.0000	0.0002	-0.0000	0.0002

	(0.0001)	(0.0002)	(0.0001)	(0.0002)	(0.0001)	(0.0002)
PTS	-0.0091***	-0.0147**	-0.0083**	-0.0134*	-0.0086**	-0.0148**
	(0.0034)	(0.0071)	(0.0036)	(0.0075)	(0.0034)	(0.0070)
Adj. Polity	-0.0000	-0.0009	-0.0001	-0.0013	0.0002	-0.0010
	(0.0007)	(0.0013)	(0.0007)	(0.0012)	(0.0007)	(0.0013)
ASPA	0.0008	0.0157	0.0107*	0.0328***	0.0029	0.0167
	(0.0050)	(0.0134)	(0.0056)	(0.0109)	(0.0048)	(0.0135)
Observations	3022	3022	3022	3022	3022	3022
R-squared	0.1093	0.4928	0.1145	0.4932	0.1184	0.4936

Notes: Dependent variables are annual GDP growth rates in 2010 USD for Column 1, 3 and 5. Dependent variables are annual average Nighttime light growth for Columns 2, 4 and 6. The model includes country and year fixed effects. Independent variables include US and UN sanctions dummies and separate dummies for their respective type: arms, military, financial, trade, travel and others. Controls also include sanctions related to the American Service-Members' Protection Act (ASPA), lagged GDP growth, lagged population growth, Political Terror Scale indicator, Trade as a percentage of GDP and an adjusted Polity indicator (0 indicating strongly autocratic, 20 indicating strongly democratic; missing values set to 10). US trade sanctions show a significant reduction in GDP growth of 2.4% but are insignificant for NTL. UN arms and military sanctions are significant but of opposite signs.

Robust standard errors in parentheses

*** *p<.01, ** p<.05, * p<.1*

become weakly significant both for GDP and NTL, with lagged UN sanctions becoming significant at 95%, increasing GDP by 9%. The unexpected sign of the lagged variable may be explained diminishing returns over time, as non-lagged variables show a negative sign, while lagged UN variables show a positive one. Both lagged and non-lagged US sanctions have a negative sign, suggesting that this may be a specific feature of UN sanctions.

Columns 3 and 4 show the same regression with sanctions being separated by severity. Only the lags of moderate and severe US sanctions have a significant effect, both only for NTL growth, with moderate sanctions decreasing it by 4% and severe sanctions increasing it by 10%. Only the moderate sanctions pair both have negative signs, with other US sanctions showing opposites. For UN sanctions we see a similar trend: a negative non-lag being followed by a positive lag, the only exception being severe UN sanctions. Mild UN sanctions are weakly significant for GDP (7% decrease), with the lagged variable being significant at 95% (10% increase). Moderate UN sanctions are also significant for NTL, showing a decrease of 10% for the non-lag and a 9% increase for the lagged variable. The size of the lags nearly offsets the values of the non-lags, implying a short-duration for sanction effectiveness. A separate regression was also made with lagged sanctions per type, but the amount of total control variables makes it difficult to interpret and may leave too little natural variation, particularly for UN sanctions. A table of the regression is nonetheless included in

Table 7

FE regression of aggregate sanctions and sanctions by severity with lags

	(1) %GDP	(2) %NTL	(3) %GDP	(4) %NTL
US sanctions	-0.0042	-0.0151		
	(0.0053)	(0.0120)		
Lagged US sanct.	-0.0092*	-0.0055		
	(0.0055)	(0.0132)		
UN sanctions	-0.0576*	-0.1001*		
	(0.0341)	(0.0559)		
Lagged UN sanct.	0.0917**	0.0990*		
	(0.0375)	(0.0528)		
Lagged GDP growth	0.1681*		0.1769*	
	(0.0959)		(0.0981)	
Lagged pop. growth	-0.4039*	0.4089	-0.3961*	0.4640
	(0.2415)	(0.3350)	(0.2256)	(0.3175)
ASPA	0.0102*	0.0324***	0.0008	0.0351**
	(0.0053)	(0.0110)	(0.0071)	(0.0167)
PTS	-0.0087**	-0.0136*	-0.0095***	-0.0154**
	(0.0035)	(0.0074)	(0.0033)	(0.0068)
Adj. Polity	-0.0003	-0.0013	-0.0003	-0.0013
	(0.0006)	(0.0012)	(0.0006)	(0.0011)
Trade %GDP	-0.0000	0.0003	-0.0000	0.0003
	(0.0001)	(0.0002)	(0.0001)	(0.0002)
US mild			0.0061	-0.0331
			(0.0077)	(0.0200)
Lagged US mild			-0.0088	0.0137
			(0.0061)	(0.0144)
US moderate			-0.0042	0.0145
			(0.0074)	(0.0151)
Lagged US moderate			-0.0122	-0.0406**
			(0.0095)	(0.0183)
US severe			-0.0113	-0.0310
			(0.0242)	(0.0733)
Lagged US severe			0.0259	0.1005**
			(0.0288)	(0.0441)
UN mild			-0.0707*	-0.0980
			(0.0397)	(0.0739)
Lagged UN mild			0.0987**	0.0963
			(0.0443)	(0.0724)
UN moderate			-0.0296	-0.1050**
			(0.0447)	(0.0470)
Lagged UN moderate			0.0629	0.0920**
			(0.0484)	(0.0441)
UN severe			-0.2435	-0.1251
			(0.1653)	(0.0943)
Lagged UN severe			0.2316	-0.0077
			(0.1724)	(0.0515)
_cons	0.0395**	0.2022***	0.0407**	0.2016***
	(0.0172)	(0.0346)	(0.0184)	(0.0334)
Observations	3022	3022	3022	3022

R-squared	0.1291	0.4943	0.1437	0.4976

Notes: Dependent variables are annual GDP growth rates in 2010 USD for Column 1 and 3. Dependent variables are annual average Nighttime light growth for Columns 2 and 4. The model includes country and year fixed effects. Independent variables include US and UN sanctions dummies and separate dummies for their respective severity: arms, military, financial, trade, travel and others. The regression also includes lagged variables of these sanction dummies. Controls also include sanctions related to the American Service-Members' Protection Act (ASPA), lagged GDP growth, lagged population growth, Political Terror Scale indicator, Trade as a percentage of GDP and an adjusted Polity indicator (0 indicating strongly autocratic, 20 indicating strongly democratic; missing values set to 10). Many of the lag pair have opposite signs, with the non-lag being negative and the lag being positive. Lagged aggregate US sanctions are only weakly significant for NTL, while lagged UN sanctions are significant for GDP (increase of 9%) and weakly significant for the rest. In terms of severity, lagged US sanctions are significant for NTL and point to a 4% decrease for moderate and 10% increase for severe sanctions. UN sanction show significance for GDP, with mild and lagged mild sanctions showing a 7% decrease (at 90% confidence) and 9% increase (95% confidence). UN moderate sanctions show significance for NTL, indicating a 10% decrease and 9% increase for the non-lagged and lagged dummy respectively. Difference in signs may suggest diminishing effects of sanctions over time
Robust standard errors in parentheses

*** $p<.01$, ** $p<.05$, * $p<.1$

the Appendix. While these results are, admittedly, not enough on their own to gauge the effectiveness of sanctions over time, they do lend credence to the "naïve" theory of sanctions, which indicates diminishing effects of sanctions.

5. Robustness and Sensitivity checks

Sensitivity to controls

As has been mentioned in the Data section and partially shown in the results, there is a tradeoff between adding more controls and having more variation in the data. This is in part due to the fact that countries who were the targets of sanctions often do not have available indicators for the period. In order to not exclude potentially meaningful observations, an assumption was made regarding the Polity database, namely to replace missing variables with the neutral state of 10. While not a perfect solution, a similar technique was used for periods of interregnum or anarchy by the Polity V database, setting the missing values to 0 to reflect the neutral state. Values for periods classified as "interruption", often the result of foreign occupation, are treated as missing entirely. It is these missing values due to "interruption" that have also be adjusted take the neutral value of 10 (or 0 using the original scale) A similar issue arose when trying to add the trade indicator, but a similar procedure was not possible. As such 4 sets of regressions are run for both GDP and NTL in Tables 8 and 9 respectively

Column 1 of Table 8 shows the first set encompassing the maximum number of observations with the adjusted Polity score, Column 2 shows the results from keeping the original Polity score[4], Column 3 shows a combination of adjusted Polity and Trade indicators, and finally Column 4 shows the unadjusted Polity score and the Trade indicator. The Columns have been

[4] The original polity score referenced here is the "polity2" variable from the Polity database (while still being modified to the 0-20 scale), which is different from the "polity" variable in the original database in which

Table 8

Sensitivity to Controls, %GDP growth FE regression

	(1)	(2)	(3)	(4)
	%GDP growth	%GDP growth	%GDP growth	%GDP growth
US arms	0.0108	0.0074	0.0120*	0.0102
	(0.0069)	(0.0062)	(0.0070)	(0.0062)
UN arms	-0.0073	-0.0009	-0.0717*	-0.0931**
	(0.0277)	(0.0288)	(0.0381)	(0.0446)
US military	-0.0032	-0.0028	-0.0025	-0.0033
	(0.0057)	(0.0057)	(0.0058)	(0.0061)
UN military	-0.0044	-0.0081	0.0598	0.0887*
	(0.0336)	(0.0365)	(0.0389)	(0.0468)
US trade	-0.0252***	-0.0273***	-0.0242**	-0.0278***
	(0.0095)	(0.0088)	(0.0109)	(0.0098)
UN trade	0.0079	0.0170	0.0403	0.0569**
	(0.0172)	(0.0189)	(0.0244)	(0.0239)
US financial	0.0132	0.0163**	0.0045	0.0105
	(0.0090)	(0.0076)	(0.0085)	(0.0069)
UN financial	0.0273	0.0322	-0.0353	-0.0466
	(0.0352)	(0.0372)	(0.0265)	(0.0316)
US travel	-0.0084	-0.0162	-0.0017	-0.0137
	(0.0181)	(0.0155)	(0.0179)	(0.0160)
UN travel	0.0163	0.0079	0.0783**	0.0873**
	(0.0427)	(0.0371)	(0.0362)	(0.0396)
US other	0.0043	-0.0037	-0.0031	-0.0101
	(0.0168)	(0.0147)	(0.0161)	(0.0143)
UN other	-0.0206	-0.0126	-0.0787**	-0.0593
	(0.0300)	(0.0261)	(0.0393)	(0.0383)
Lagged GDP growth	0.2123***	0.2225***	0.1614	0.1662
	(0.0766)	(0.0804)	(0.0992)	(0.1053)
Lagged pop. growth	-0.1222	-0.0200	-0.4014*	-0.3497
	(0.3257)	(0.3273)	(0.2398)	(0.2280)
PTS	-0.0113***	-0.0125***	-0.0086**	-0.0103***
	(0.0034)	(0.0032)	(0.0034)	(0.0031)
Adj. Polity	-0.0002		0.0002	
	(0.0007)		(0.0007)	
ASPA	0.0054	0.0044	0.0029	0.0016

interregnum periods are also listed as missing instead of neutral. The polity2" variable was added in the most recent Polity V version in 2018.

	(0.0050)	(0.0049)	(0.0048)	(0.0049)
Orig. Polity		-0.0004		0.0003
		(0.0006)		(0.0006)
Trade %GDP			-0.0000	-0.0001
			(0.0001)	(0.0001)
Observations	3313	3258	3022	2981
R-squared	0.1382	0.1504	0.1184	0.1350

Notes: Dependent variables are annual GDP growth rates in 2010 USD. The model includes country and year fixed effects. Independent variables include US and UN sanctions dummies and separate dummies for their respective type: arms, military, financial, trade, travel and others. Controls also include sanctions related to the American Service-Members' Protection Act (ASPA), lagged GDP growth, lagged population growth, Political Terror Scale indicator, Trade as a percentage of GDP and an adjusted Polity indicator (0 indicating strongly autocratic, 20 indicating strongly democratic; missing values set to 10) and the "original" Polity indicator (0 indicating strongly autocratic, 20 indicating strongly democratic; missing values are not treated). Column 1 includes the adjusted Polity score. Column 2 uses the original Polity score. Column 3 uses both the adjusted Polity score and Trade as a percent of GDP. Column 4 uses the original Polity score and Trade as a percent of GDP. GDP data seems sensitive to control list, with UN sanctions being particularly affected. Only US trade sanctions are consistently significant at all four specifications.

Robust standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

ordered by number of observations included in the regression in a descending order. The US estimates for GDP seem more robust to changes, with trade retaining its significance in all 4 specifications. Financial sanctions become significant when using the original Polity score, but are of the wrong sign and loses significance once the trade indicator is also factored in. Similarly, US arms sanctions only become significant with adjusted Polity and trade, but are of the wrong sign and remain insignificant in other specifications. UN sanctions seem more susceptible to changes in control variables, with 5 out of 6 sanction types becoming significant at 90 or 95% in one or more sets of controls.

Table 9 shows the results from different control sets for NTL growth. Nighttime lights estimates seem in general more stable to different sets of controls. US sanctions remain insignificant across all control sets. UN sanctions seem to change when the trade indicator is added as a control, with arms sanctions being reduced from 5.2% to 1.1% reduction in NTL growth and military sanctions becoming significant, albeit with a wrong sign. Others category of UN sanctions also become weakly significant but only while using the adjusted Polity values with trade being included as control.

It is difficult to say if these more stable estimates have a stronger causal relationship than GDP and which set of controls best facilitates it. On the one hand, adding more control variables helps to isolate the effect of sanctions on both GDP and NTL. On the other, it also

Table 9

Sensitivity to Controls, %NTL growth FE regression

	(1)	(2)	(3)	(4)
	%NTL growth	%NTL growth	%NTL growth	%NTL growth
US arms	0.0158	0.0121	0.0077	0.0065
	(0.0152)	(0.0141)	(0.0140)	(0.0132)
UN arms	-0.0658**	-0.0527**	-0.1103**	-0.1104**
	(0.0292)	(0.0262)	(0.0532)	(0.0531)
US military	-0.0012	-0.0012	-0.0006	-0.0036
	(0.0123)	(0.0123)	(0.0126)	(0.0127)
UN military	0.0220	0.0147	0.0731**	0.0888**
	(0.0301)	(0.0274)	(0.0365)	(0.0384)
US trade	0.0116	0.0078	0.0204	0.0129
	(0.0169)	(0.0163)	(0.0181)	(0.0177)
UN trade	-0.0342	-0.0214	-0.0250	-0.0219
	(0.0268)	(0.0290)	(0.0185)	(0.0191)
US financial	-0.0145	-0.0077	-0.0237	-0.0134
	(0.0163)	(0.0147)	(0.0163)	(0.0153)
UN financial	0.0411	0.0430	-0.0168	-0.0232
	(0.0524)	(0.0532)	(0.0294)	(0.0303)
US travel	0.0356	0.0059	0.0379	0.0079
	(0.0252)	(0.0204)	(0.0239)	(0.0198)
UN travel	-0.0331	-0.0147	0.0226	0.0487
	(0.0479)	(0.0438)	(0.0353)	(0.0346)
US other	0.0001	-0.0128	-0.0121	-0.0216
	(0.0276)	(0.0232)	(0.0234)	(0.0205)
UN other	-0.0027	-0.0092	-0.0670*	-0.0502
	(0.0335)	(0.0275)	(0.0397)	(0.0347)
Lagged pop. growth	0.5386	0.7156*	0.4171	0.5658*
	(0.3697)	(0.3717)	(0.3370)	(0.3404)
PTS	-0.0161**	-0.0182***	-0.0148**	-0.0176***
	(0.0071)	(0.0065)	(0.0070)	(0.0065)
Adj. Polity	-0.0009		-0.0010	
	(0.0013)		(0.0013)	
ASPA	0.0164	0.0163	0.0167	0.0168
	(0.0131)	(0.0131)	(0.0135)	(0.0135)
Orig. Polity		-0.0017		-0.0014
		(0.0012)		(0.0012)

Trade %GDP			0.0002	0.0001
			(0.0002)	(0.0002)
Observations	3313	3258	3022	2981
R-squared	0.4729	0.4764	0.4936	0.4968

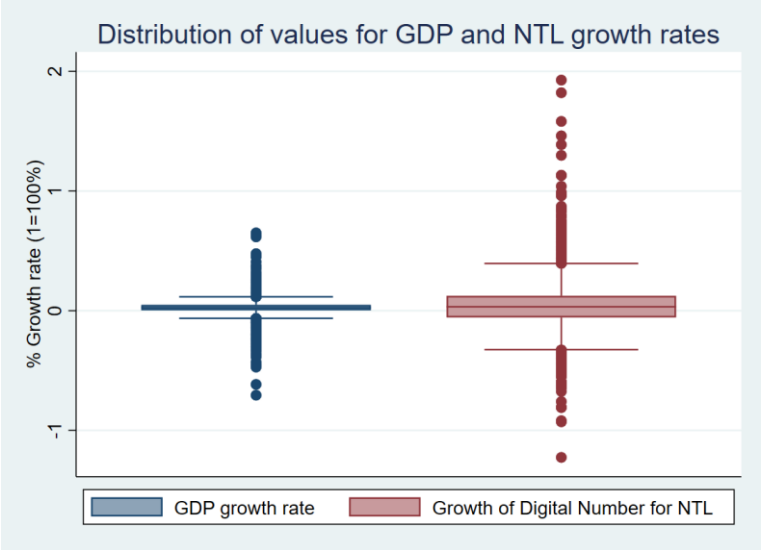
Notes: Dependent variables are annual average NTL growth rates. The model includes country and year fixed effects. Independent variables include US and UN sanctions dummies and separate dummies for their respective type: arms, military, financial, trade, travel and others. Controls also include sanctions related to the American Service-Members' Protection Act (ASPA), lagged population growth, Political Terror Scale indicator, Trade as a percentage of GDP and an adjusted Polity indicator (0 indicating strongly autocratic, 20 indicating strongly democratic; missing values set to 10) and the "original" Polity indicator (0 indicating strongly autocratic, 20 indicating strongly democratic; missing values are not treated). Column 1 includes the adjusted Polity score. Column 2 uses the original Polity score. Column 3 uses both the adjusted Polity score and Trade as a percent of GDP. Column 4 uses the original Polity score and Trade as a percent of GDP. NTL data seem slightly more consistent, with fewer variables being significant in one specification and insignificant in the other. Only UN arms sanctions are significant across all four control sets, jumping from around 6% to 11% once trade is controlled for.

* p<0.10, ** p<0.05, *** p<0.01

reduces the sample size, with the observations being dropped often being sanctioned. Out of the 292 observations with missing trade indicators (8% of the total sample), 188 experienced US sanctions (11% of total US sanctions) and 78 UN sanctions (36% of total UN sanction observations). For reference, the total observations featuring sanctions are 1700 and 215 for US and UN respectively. While there are plenty of US sanction cases to still draw meaningful conclusions, the low number of UN observations make it more difficult to isolate the causal effect. This is further made difficult by the fact that there are no cases of UN sanctions without US sanctions being already in effect. A combination of these factors may be the reason why the effect of some UN sanctions are of the wrong sign while still being significant and why this study refrains from making conclusions regarding them.

Outliers

Another potential weakness of the data is the presence of outliers. As seen in Graph 6, both GDP and NTL estimates show variables that lie outside of the whiskers, indicating outlier variables. Closer examination of the data show that some extreme negative (positive) GDP growth can be seen during (or after) an armed conflict. Another set seems to be related to the high volatility of many post-communist countries as they transition towards market economies. The exception to this seems to be Equatorial Guinea in which large oil reserves were discovered, and Azerbaijan, after it began exporting oil and gas. NTL outlier variables seem to be more random and related to specific years. This is likely resulting from the occasional switch to a newer satellite at the beginning of the year, which should be captured



Graph 6

by the year fixed effects. Neither estimate is further treated, NTL due to the presence of year fixed effects, and GDP due to outliers often being part of sanction cases.

One variable which has been included in other papers on sanctions, but has so far remained undiscussed, is the role of active conflict. Whether in the form of civil wars or fought between individual states, conflict has an influence on both GDP and Nighttime lights. However, many sanctions imposed on countries have been made as a response to and in an effort to stop such conflicts. As such, minor and major conflicts can be seen as endogenous variables, whose inclusion may restrict us from observing the full effect of sanctions, constituting a bad control. Regressions including them are added to the Appendix for reference, drawing data on conflicts from the UCDP/PRIO Armed Conflict Dataset.

6. Conclusion

The study finds mixed evidence in regards to the effects of sanctions on economic growth and activity. US sanctions have been found to have a significant impact on GDP and NTL growth, reducing them by 1.1% and 1.9% respectively. Separating them by severity leaves only moderate sanctions significant at 1.6% and 1.9% reduction in growth for GDP and NTL. This suggests diminishing returns of increasing trade restrictions, potentially due to the target finding new trade partners as time goes on. Further disaggregating by time shows a 2.4% reduction in GDP for trade sanctions, with all others being insignificant. Trade sanctions do, however, lose their significance when it comes to NTL growth, potentially a result of black market activity and realignment of the economy not reflected in official national accounts. In

summary, US trade sanctions have shown to have significant impact on a country's GDP growth, while US sanctions as a whole show an ability to reduce a country's growth both in GDP and in Nighttime lights. The same cannot be said for UN sanctions, however. While the literature suggests a more pronounced effect of sanctions by the international body, isolating the effect has proven to be a challenge. The low number of UN sanction cases, coupled with missing indicators for sanctioned periods make it difficult to isolate draw meaningful conclusions, sometimes resulting in counterintuitive results.

Nighttime lights offer a unique perspective into the effects of sanctions on a target's economy. By providing an unbiased and consistently available indicator across all countries and recent years, NTL estimates potentially allow for a more accurate picture of economic activity that is not as easily captured by traditional economic indicators. Grey and black sectors, which would be positively affected by sanctions but not factor into GDP, could reduce the effect of sanctions. This result seems to be confirmed by the significance of trade sanctions regarding GDP growth, while also seemingly having an insignificant effect on NTL growth. The differences between GDP and NTL significances may also allow researchers to measure how grey and black markets respond to sanctions, although further research will need be conducted to better understand this interaction. Comparing and contrasting the results from GDP and NTL has, nonetheless, yielded interesting observations, indicating that trade sanctions may have reduced effects, but also hinting that comprehensive US sanctions are able to cause more economic disruptions than indicated by GDP. Furthermore, NTL estimates seem to be more robust to various specifications, potentially allowing for it to be used as an independent variable where other statistics are not easily obtainable.

With modern sanctions becoming more targeted and precise in applying economic damage, it is nonetheless important to gauge the effects of sanctions on a macro level, at the very least in order to check for unanticipated ripple effects. Better knowledge on the effects of sanctions, both traditional and targeted, can help facilitate more informed decision making and provide more realistic expectations. The 2% reduction in GDP growth induced by US trade sanctions is certainly sizeable, but the full potential of sanctions may require a comprehensive sanctions plan in order to have an effect on NTL and the broader economy. Within the context of the current crisis, it is difficult to draw conclusions regarding the potential economic damage. Nonetheless, more research into the economic effects using modern databases and more recent time periods may help, both at understanding the effects of current sanctions levied against Russia and for future cases down the line.

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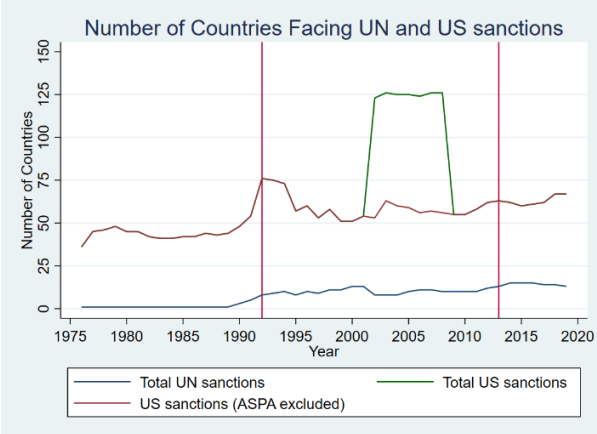
Appendix

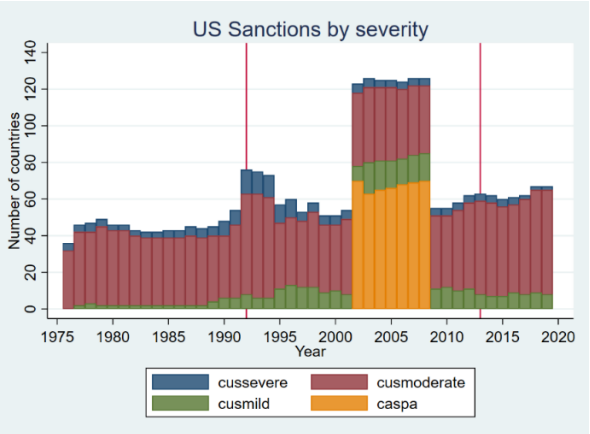
Table A1

Country List

Afghanistan, Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Belarus, Belgium, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Central African Republic, Chad, Chile, China, Colombia, Comoros, Congo, Democratic Republic of the Congo, Costa Rica, Croatia, Cuba, Cyprus, Denmark, Djibouti, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Estonia, Eswatini, Ethiopia, Fiji, Finland, France, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hungary, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, South Korea, Kuwait, Kyrgyzstan, Lao People's Democratic Republic, Latvia, Lebanon, Lesotho, Liberia, Libya, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Mali, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Montenegro, Morocco, Mozambique, Myanmar, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, North Macedonia, Norway, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russia, Rwanda, Saudi Arabia, Senegal, Serbia, Sierra Leone, Singapore, Slovakia, Slovenia, Solomon Islands, Somalia, South Africa, Spain, Sri Lanka, Sudan, Suriname, Sweden, Switzerland, Syria, Tajikistan, Thailand, Timor-Leste, Togo, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United Arab Emirates, United Kingdom, Uruguay, Uzbekistan, Venezuela, Viet Nam, Yemen, Zambia, Zimbabwe



Graph A1



Graph A2

Table A2

Controls-Conflict FE regression

	(1)	(2)	(3)	(4)
	%GDP growth	%NTL growth	%GDP growth	%NTL
US sanctions	-0.0107*	-0.0168**	-0.0107**	-0.0184**
	(0.0061)	(0.0073)	(0.0049)	(0.0076)
UN sanctions	0.0067	-0.0222	0.0096	-0.0279
	(0.0104)	(0.0193)	(0.0106)	(0.0210)
Minor conflict	-0.0213***	-0.0290**	-0.0178**	-0.0281**
	(0.0074)	(0.0136)	(0.0075)	(0.0129)
Major conflict	-0.0702***	-0.0695***	-0.0576***	-0.0554**
	(0.0167)	(0.0242)	(0.0191)	(0.0228)
ASPA	0.0108	0.0274**	0.0097*	0.0313***
	(0.0069)	(0.0106)	(0.0050)	(0.0109)
Lagged pop. growth		0.5018	-0.3643	0.4608
		(0.3743)	(0.2752)	(0.3703)
Lagged GDP growth			0.1606*	
			(0.0942)	
PTS			-0.0033	-0.0079
			(0.0032)	(0.0073)
Adj. Polity			-0.0001	-0.0011
			(0.0006)	(0.0012)
Trade %GDP			-0.0000	0.0003
			(0.0001)	(0.0002)
_cons	-0.0011	0.1697***	0.0258*	0.1900***
	(0.0083)	(0.0205)	(0.0155)	(0.0333)
Observations	3318	3313	3022	3022
R-squared	0.0946	0.4732	0.1280	0.4940

Notes: Dependent variables are annual GDP growth rates in 2010 USD for Column 1 and 3. Dependent variables are annual average Nighttime light growth for Columns 2 and 4. The model includes country and year fixed effects.

Robust standard errors in parentheses

Table A3

Conflict FE regression by severity sanction type

	(1)	(2)	(3)	(4)
	%GDP	%NTL	%GDP	%NTL
Minor conflict	-0.0199***	-0.0297**	-0.0183**	-0.0298**
	(0.0076)	(0.0132)	(0.0071)	(0.0135)
Major conflict	-0.0619***	-0.0614***	-0.0542***	-0.0583***
	(0.0203)	(0.0222)	(0.0179)	(0.0214)
Lagged GDP growth	0.1595*		0.1519	
	(0.0930)		(0.0973)	
Lagged pop. growth	-0.3363	0.5158	-0.4266*	0.3966
	(0.2683)	(0.3663)	(0.2510)	(0.3348)
Trade %GDP	0.0000	0.0003	0.0000	0.0002
	(0.0001)	(0.0002)	(0.0001)	(0.0002)
PTS	-0.0034	-0.0081	-0.0034	-0.0086
	(0.0030)	(0.0070)	(0.0029)	(0.0069)
Adj. Polity	-0.0004	-0.0014	0.0001	-0.0011
	(0.0007)	(0.0012)	(0.0007)	(0.0013)
US mild	0.0008	-0.0230		
	(0.0062)	(0.0158)		
US moderate	-0.0162**	-0.0182**		
	(0.0064)	(0.0081)		
US severe	0.0242	0.0762		
	(0.0350)	(0.0633)		
UN mild	-0.0079	-0.0347		
	(0.0188)	(0.0277)		
UN moderate	0.0203	-0.0314		
	(0.0144)	(0.0209)		
UN severe	-0.0895*	-0.1871**		
	(0.0478)	(0.0877)		
ASPA	-0.0003	0.0356**	0.0024	0.0162
	(0.0071)	(0.0165)	(0.0047)	(0.0133)
US arms			0.0124	0.0091
			(0.0075)	(0.0143)
UN arms			-0.0532	-0.0913
			(0.0380)	(0.0578)
US military			-0.0012	0.0006
			(0.0055)	(0.0126)
UN military			0.0366	0.0471

			(0.0391)	(0.0395)
US trade			-0.0207**	0.0248
			(0.0103)	(0.0180)
UN trade			0.0302	-0.0352*
			(0.0231)	(0.0195)
US financial			0.0030	-0.0251
			(0.0084)	(0.0161)
UN financial			-0.0278	-0.0053
			(0.0270)	(0.0300)
US travel			-0.0022	0.0352
			(0.0180)	(0.0242)
UN travel			0.0702**	0.0142
			(0.0329)	(0.0363)
US other			-0.0037	-0.0127
			(0.0164)	(0.0239)
UN other			-0.0669*	-0.0564
			(0.0383)	(0.0423)
Observations	3022	3022	3022	3022
R-squared	0.1369	0.4954	0.1372	0.4954

Notes: Dependent variables are annual GDP growth rates in 2010 USD for Column 1 and 3. Dependent variables are annual average Nighttime light growth for Columns 2 and 4. The model includes country and year fixed effects.

Robust standard errors in parentheses

**** p<.01, ** p<.05, * p<.1*

Table A4
FE regression by sanction type with lags

	(1) %GDP	(2) %NTL	(3) %GDP	(4) %NTL
US arms	0.0120*	0.0077	-0.0179	-0.0125
	(0.0070)	(0.0140)	(0.0168)	(0.0242)
UN arms	-0.0717*	-0.1103**	-0.1141	-0.3444
	(0.0381)	(0.0532)	(0.1028)	(0.2110)
US military	-0.0025	-0.0006	0.0103	0.0087
	(0.0058)	(0.0126)	(0.0070)	(0.0206)
UN military	0.0598	0.0731**	0.0666	0.2721
	(0.0389)	(0.0365)	(0.0982)	(0.1910)
US trade	-0.0242**	0.0204	-0.0156	0.0550***
	(0.0109)	(0.0181)	(0.0109)	(0.0205)
UN trade	0.0403	-0.0250	0.0626	-0.0033
	(0.0244)	(0.0185)	(0.0465)	(0.0367)
US financial	0.0045	-0.0237	0.0030	-0.0069
	(0.0085)	(0.0163)	(0.0082)	(0.0183)
UN financial	-0.0353	-0.0168	-0.0358	-0.0036
	(0.0265)	(0.0294)	(0.0504)	(0.0526)
US travel	-0.0017	0.0379	-0.0197	0.0194
	(0.0179)	(0.0239)	(0.0166)	(0.0246)
UN travel	0.0783**	0.0226	0.0952**	0.0484
	(0.0362)	(0.0353)	(0.0460)	(0.0677)
US other	-0.0031	-0.0121	-0.0151	-0.0621**
	(0.0161)	(0.0234)	(0.0102)	(0.0244)
UN other	-0.0787**	-0.0670*	-0.1832**	-0.1355
	(0.0393)	(0.0397)	(0.0820)	(0.0912)
Lagged GDP growth	0.1614		0.1577	
	(0.0992)		(0.0966)	
Lagged pop. growth	-0.4014*	0.4171	-0.4445**	0.6921
	(0.2398)	(0.3370)	(0.2200)	(0.4392)
Trade %GDP	-0.0000	0.0002	-0.0000	0.0001
	(0.0001)	(0.0002)	(0.0001)	(0.0003)
PTS	-0.0086**	-0.0148**	-0.0077***	-0.0205**
	(0.0034)	(0.0070)	(0.0029)	(0.0082)
Adj. Polity	0.0002	-0.0010	0.0002	-0.0001
	(0.0007)	(0.0013)	(0.0007)	(0.0017)
ASPA	0.0029	0.0167	0.0015	0.0171
	(0.0048)	(0.0135)	(0.0049)	(0.0158)
Lagged US arms			0.0269	0.0289
			(0.0182)	(0.0229)
Lagged UN arms			0.1095	0.2950
			(0.1269)	(0.2137)
Lagged US military			-0.0131**	-0.0090
			(0.0063)	(0.0149)
Lagged UN military			-0.0355	-0.2666
			(0.1170)	(0.2129)
Lagged US trade			-0.0176	-0.0317
			(0.0109)	(0.0257)
Lagged UN trade			-0.0586	-0.0019
			(0.0614)	(0.0356)
Lagged US financial			0.0033	-0.0299
			(0.0086)	(0.0184)
Lagged UN financial			0.0006	-0.0231
			(0.0591)	(0.0712)
Lagged US travel			0.0222	0.0473
			(0.0185)	(0.0331)
Lagged UN travel			-0.0372	-0.0444

			(0.0558)	(0.0845)
Lagged US other			0.0183	0.0470
			(0.0135)	(0.0307)
Lagged UN other			0.1700**	0.0906
			(0.0814)	(0.0952)
Lagged %NTL growth				-0.3357***
				(0.0251)
_cons	0.0325*	0.1998***	0.0323*	0.0715*
	(0.0185)	(0.0330)	(0.0179)	(0.0376)
Observations	3022	3022	3022	2895
R-squared	0.1184	0.4936	0.1662	0.5704

Notes: Dependent variables are annual GDP growth rates in 2010 USD for Column 1 and 3. Dependent variables are annual average Nighttime light growth for Columns 2 and 4. The model includes country and year fixed effects.
Robust standard errors are in parentheses
**** p<.01, ** p<.05, * p<.1*