Supplementary Appendices for:

"Exploring the Final Frontier:
An Empirical Analysis of Global Civil Space Proliferation"
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Appendix 1: Modeling Olympic Medal Performance

Description of Procedures: A series of models have been developed by economists to predict how countries perform in the Olympic Games (Bernard and Busse 2004; Johnson and Ali 2004). In recent years, models such as these have been used to make out-of-sample predictions about how countries will perform in Olympic Games and they have tended to yield fairly accurate results (Heuslein 2010). The key variables that these studies have identified are fairly simplistic: population, GDP per capita, regime type, and whether a country is hosting the games. To account for population and GDP per capita, I used the logged real GDP per capita (*LnGDPpc*) and logged population (*LnPopulation*) counts from Gleditch (2008). To account for regime type, I use Marshall and Jaggers' (2009) polity2 variable (*Polity2*). I also include the square value of the figure, because totalitarian states and liberal democracies may perform better than anocracies (*Polity2-Squared*). I code a dummy variable for whether or not a country is hosting the games (*Hosting Nation*), as that has been shown to give a home crowd advantage (1=Yes; 0=No). To account for the political salience of the Olympic Games, a dummy variable for whether the Olympics took place during the Cold War (*Cold War*) or after it (1=During; 0=After) is included. Lastly, I also include a time variable to denote the number of years since the Olympic Games were restarted after World War II (*Years*). The dependent variable is the combined total of events that a country receives the bronze, silver, or gold medal in during an Olympic Games (*Medal Count*). The unit of analysis of this model is the year in which the Summer Olympic Games are held, which occurs every four years. Summary statistics for the model are displayed in *Table 1*.

TABLE 1. Summary Statistics for Model Account Model Variables

	Obs.	Mean	Std. Dev.	Min	Max
Medal Count	2204	4.78	14.77	0	195
LnPopulation	2032	8.66	1.88	2.86	14.07
LnGDP per capita	2032	8.24	1.11	5.23	11.20
Polity2	1954	.25	7.54	-10	10
Polity2-Squared	1954	58.86	32.32	0	100
Hosting Nation	2204	.01	.08	0	1
Cold War	2204	.62	.48	0	1
Years	2204	36.76	16.75	3	62

To generate accurate predictions of how countries' medal counts at the quadrennial Summer Olympics from 1952-2004, I employ a negative binomial estimator appropriate for use with count variables. *Table 2* displays the results of running the analysis using robust standard errors to account for

heteroskedasticity. The variables behave very much as the literature suggests they should. The only somewhat puzzling result is that *Cold War* has a negative effect on medal count figures. This could be explained in part by the fact that the number of events in which Olympic medals are rewarded has grown in recent years relative to the past. This model should thus provide a sound framework for generating in-sample predictions regarding Olympic performance that can serve as the basis for comparison in identifying overachieving states.

TABLE 2. Negative Binomial Regression of Medal Counts

	Model 1
LnPopulation	.86***
	(.04)
LnGDP per capita	1.18***
	(.080
Polity2	-.04***
	(.01)
Polity2-Squared	.01***
	(.00)
Hosting Nation	1.06***
	(.31)
Cold War	-.71***
	(.20)
Years	-.03***
	(.01)
Constant	-16.28***
	(.73)
Observations	1798
Prob $\chi^2 >0$	0.00

Notes. *, **, and *** denote statistical significance at the 90%, 95%, and 99% confidence levels, respectively, using one-tailed tests.

Appendix 2: Summary Information on the Variables in the Main Model

TABLE 3. Summary Statistics for the Variables in the Main Model

	Minimum	Maximum	Mean	Std. Dev.	Obs.
Civil Space Agency	0	1	0.19	0.40	6,236
Satellite Capabilities	0	1	0.12	0.33	6,236
Domestic SLC	0	1	0.04	0.21	6,236
lnGDP	2.62	16.16	9.59	2.03	6,236
Higher Education	0	30.6	3.66	4.28	6,236
lnGDPxHE	0	494.46	39.63	52.87	6,236
lnTrade Openness	-11.99	3.45	-1.70	1.25	6,236
LRBMs	0	1	0.04	0.20	6,236
Major Power	0	1	0.04	0.21	6,236
Military R&D Years	0	82	5.64	13.27	6,236
Olympics	0	1	0.08	0.27	6,236
DSLC Rivals	0	5	0.21	0.58	6,236

Notes. The space capabilities variables reported represent their possession variants.

TABLE 4. Pairwise Correlations of the Independent Variables in the Main Model

	C.S.A.	Higher Ed.	lnGDP	lnGDPxHE	Maj. Pow.	Olymp.	Mil. R&D	LRBMs	lnTr.	DSLC Riv.
Civil Space Agency	1.00									
Higher Education	0.43	1.00								
lnGDP	0.60	0.52	1.00							
lnGDPxHE	0.49	0.98	0.59	1.00						
Major Power	0.33	0.17	0.38	0.25	1.00					
Olympics	0.08	0.17	0.13	0.16	-0.01	1.00				
Military R&D Years	0.57	0.37	0.63	0.46	0.59	0.02	1.00			
LRBMs	0.41	0.26	0.38	0.32	0.75	0.03	0.57	1.00		
lnTrade Openness	0.04	0.21	-0.04	0.18	-0.06	0.03	-0.01	-0.05	1.00	
DSLC Rivals	0.27	0.20	0.35	0.25	0.45	0.06	0.48	0.45	-0.07	1.00

Supplementary Appendix 3: Additional Robustness Analyses

TABLE 5. Re-Analyzing the Domestic SLC Models
without *Major Power* and *Military R&D Years*

	Model 5 *Acquire*	*Model 6* *Possess*
lnGDP	1.29***	1.20***
	(0.46)	(0.43)
Higher Education	1.30***	0.90***
	(0.43)	(0.34)
lnGDPxHE	-0.10***	-0.07***
	(0.03)	(0.03)
Military R&D Years		
LRBMs	1.65***	1.73***
	(0.48)	(0.58)
Civil Space Agency	2.04***	2.72***
	(0.64)	(0.79)
DSLC Rivals	-0.15	0.25
	(0.36)	(0.36)
Major Power		
Olympics		-1.47***
		(0.44)
lnTrade Openness	-0.37***	0.10
	(0.09)	(0.11)
_Years	0.20	-0.47***
	(0.16)	(0.08)
_Years^2	-0.40	1.92***
	(0.67)	(0.43)
_Years^3	-0.02	-0.26***
	(0.08)	(0.06)
Constant	-22.91***	-16.04***
	(5.81)	(5.17)
Probability > χ^2	0.00	0.00
Observations	5,972	6,236

Notes. *, **, and *** denote statistical significance at the 90%, 95%, and 99% confidence levels, respectively, using one-tailed tests.

TABLE 6. Re-Analyzing the Main Models Using a Split Sample (Sample>mean(lnGDP))

	Civil Space Agency		Satellite Capabilities		Domestic SLC	
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
	Acquire	*Possess*	*Acquire*	*Possess*	*Acquire*	*Possess*
lnGDP	0.28**	0.28*	1.01***	1.13***	2.05***	1.78***
	(0.11)	(0.15)	(0.19)	(0.19)	(0.66)	(0.49)
Higher Education	-0.06	0.05	0.56***	0.57***	2.37***	1.74***
	(0.14)	(0.25)	(0.19)	(0.15)	(0.74)	(0.42)
lnGDPxHE	0.01	-0.00	-0.05***	-0.05***	-0.18***	-0.13***
	(0.01)	(0.02)	(0.02)	(0.01)	(0.06)	(0.03)
Military R&D Years	0.01	0.01*	0.01	0.02**	0.08**	0.08***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)
LRBMs	1.25***	1.41***	0.50*	0.41	-0.37	-0.02
	(0.35)	(0.39)	(0.28)	(0.38)	(0.76)	(0.73)
Civil Space Agency			0.49***	0.61***	1.53**	2.29**
			(0.18)	(0.21)	(0.78)	(0.98)
DSLC Rivals	-0.08	-0.02	-0.07	0.02	0.58	0.88***
	(0.07)	(0.18)	(0.11)	(0.15)	(0.61)	(0.41)
Major Power	0.07	-0.14	0.12	0.02	2.56**	2.18**
	(0.32)	(0.30)	(0.25)	(0.39)	(1.08)	(0.95)
Olympics	0.24	0.23	0.27	0.22		-0.35
	(0.18)	(0.20)	(0.28)	(0.27)		(0.23)
lnTrade Openness	0.00	0.17***	0.20**	0.40***	-0.78***	-0.27*
	(0.07)	(0.05)	(0.08)	(0.10)	(0.25)	(0.16)
_Years	0.13**	-0.50***	0.07	-0.36***	0.10	-0.50***
	(0.05)	(0.04)	(0.10)	(0.04)	(0.30)	(0.09)
_Years^2	-0.39**	1.85***	-0.34	1.12***	0.31	2.27***
	(0.20)	(0.22)	(0.34)	(0.22)	(1.04)	(0.57)
_Years^3	0.00	-0.02***	0.04	-0.11***	-0.13	-0.32***
	(0.00)	(0.00)	(0.03)	(0.03)	(0.12)	(0.09)
Constant	-6.22***	-1.34	-13.70***	-11.38***	-36.30***	-27.09***
	(1.34)	(1.59)	(2.28)	(2.27)	(8.27)	(7.02)
Probability > χ^2	0.00	0.00	0.00	0.00	0.00	0.00
Observations	1,835	2,943	2,238	2,943	2,677	2,943

*Notes.* *, **, and *** denote statistical significance at the 90%, 95%, and 99% confidence levels, respectively, using one-tailed tests.

FIGURE 1. Marginal Effects of a One-Standard Deviation Increase in Higher Education on Countries' Acquisition of Space Capabilities, Dependent upon a Country's Economic Size (Coincides with Figure 2 in the Main Text)

Calculating Change from the Mean of Higher Education
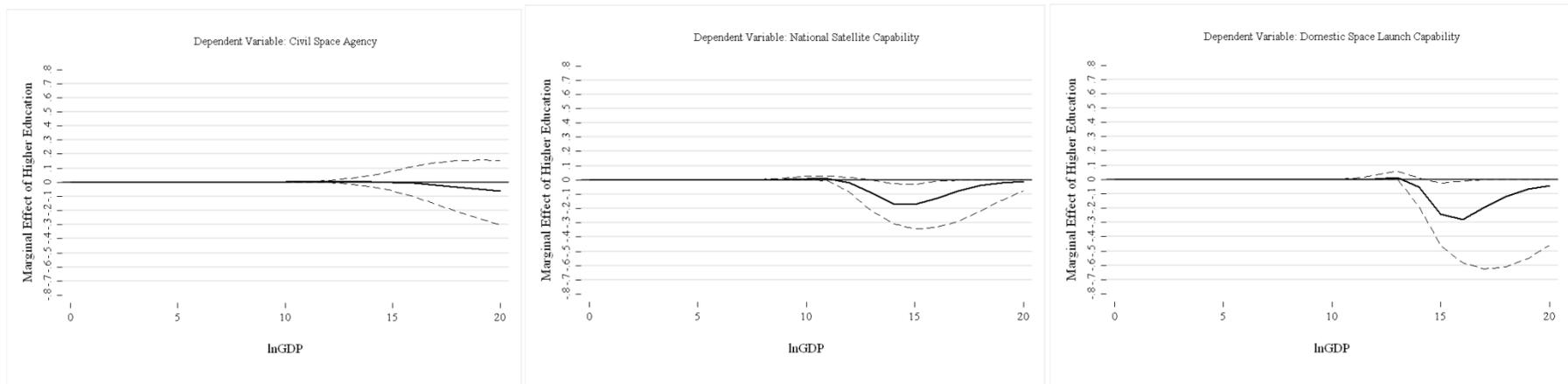
Calculating Change from 1.5 Standard Deviations above the Mean of Higher Education
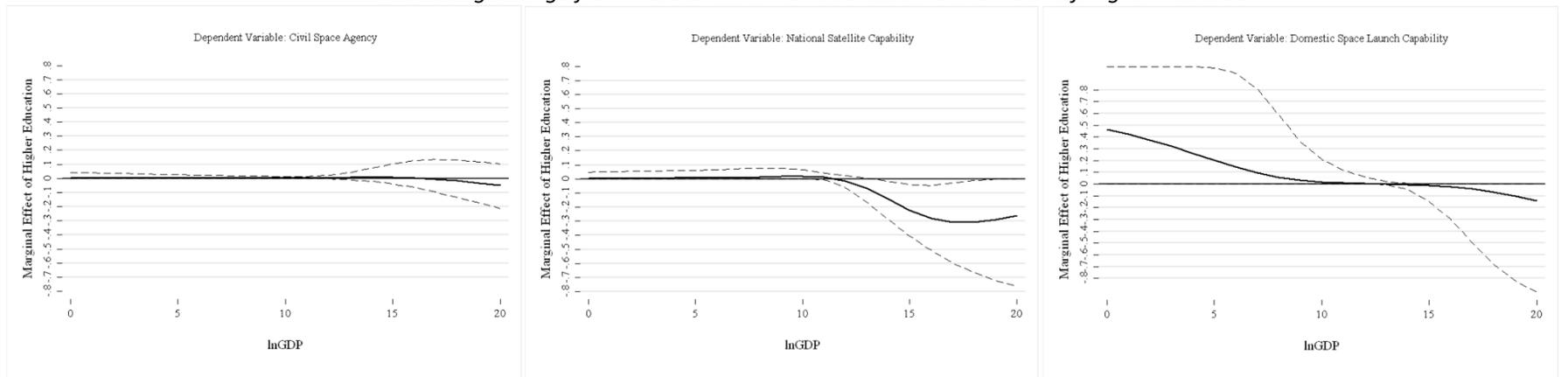
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