Exploration of Factors Leading to National R&D Expenditures

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for

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Introduction

In today's dynamic and innovation driven world, new inventions and ideas drive economic development. Consider the significant impact that such innovations as railroads, electronics, computers, and artificial intelligence have had and are having on economies. Therefore, understanding how innovations occur is an important step in understanding economic development. One measure of a country's innovation efforts is its level of R&D expenditures. This paper will explore the relationships between a country's encouragement of entrepreneurship, business friendliness, and legal structure as drivers of innovation.

The rest of this paper will be divided into the following sections: 1. Research question, this section will provide the specific statement of the paper's purpose; 2. Methodological approach and data analysis, this section will discuss the approach to be pursued and provide a review of the data used; 3. Model specifications, this section will provide the specifications for the regression models; 4. Model fit and comparisons / estimations, this section will review the results of the models and the estimations developed; 5. Conclusion, this last section will discuss the overall conclusions reached.

Data sources, Supplemental lagged variable analysis, and Stata code, can be found in appendix A, B, and C, respectively.

Research Question

Why are some countries spending more on R&D than other countries? To investigate this question three hypothesis are put forward to explain higher/lower levels of R&D expenditures: 1) Greater governmental and social encouragement of entrepreneurship, 2) Better legal structure, and 3) Governmental support for education.

Methodological Approach and Data Analysis

In order to evaluate the hypotheses a judgmental selection of fourteen countries was developed. These countries are:

Count	Sample of Countries	Count	Sample of Countries
1	Argentina	8	Italy
2	Brazil	9	Japan
3	Canada	10	Singapore
4	China	11	South Africa
5	Colombia	12	South Korea
6	France	13	UK
7	Germany	14	US

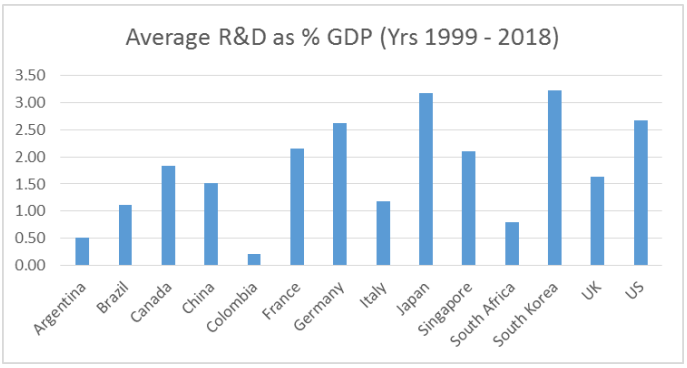
Using data on these countries and regression techniques, this paper will evaluate the research question using panel data by incorporating the following dependent variable (DV) and independent variables (IV):

Variable Description	Category	System Variable Name	Beg	End	Min.	Max.	Mean	Standard Deviation	Coefficient of variation (CV) = Standard Deviation / Mean	Missing (out of 500 potential)	Missing %
Total R&D as a percentage of GDP	Dependent Variabile	RDPERGDP	1999	2018	0.04	4.55	1.46	0.94	65%	100.00	20%
% Entrepreneurs in business services sector	Entrepreneurial	EFBSS	2000	2018	0.70	43.99	18.70	10.86	58%	208.00	42%
Cultural and social norms score	Entrepreneurial	EFCSN	2000	2018	2.01	4.59	2.96	0.51	17%	236.00	47%
% of 18-64 year olds starting business fear failure	Entrepreneurial	EFFF	2000	2018	13.91	65.32	35.75	8.23	23%	200.00	40%
% of 18-64 population that perceived they are capable starting business	Entrepreneurial	EFPC	2000	2018	8.65	83.42	43.62	14.92	34%	200.00	40%
& of 18-64 population who agree entrepreneurship is a good career choice	Entrepreneurial	EFGCC	2000	2018	22.81	92.45	61.86	13.43	22%	241.00	48%
Governmental entrepreneurial support and policies score	Entrepreneurial	EFGSP	2000	2018	1.37	3.79	2.75	0.51	19%	223.00	45%
High Job Creation Expectation	Entrepreneurial	EFJCE	2000	2018	1.62	71.51	22.39	11.68	52%	200.00	40%
Score ease of starting a business	Entrepreneurial	STARTBUSSCR	2004	2018	20.82	98.23	82.27	12.09	15%	205.00	41%
Economist Intelligence Unit's Democracy Index	Legal	DEMINDX	2006	2017	1.71	9.61	6.58	2.08	32%	250.00	50%
Score-Ease of shareholder suits index (0-10)	Legal	MINSUITSCR	2006	2018	10.00	90.00	59.45	21.77	37%	175.00	35%
Gov expenditure per student, secondary (% of GDP per capita)	Gov Support of Education	GOVEXPSEC	1999	2018	8.30	31.35	19.72	5.02	25%	301.00	60%
Proportion of seats held by women in national parliaments (%)	Other	FMPAR	1999	2018	0.00	48.20	18.80	9.88	53%	15.00	3%
GINI index (World Bank estimate)	Other	GINI	2010	2018	28.50	64.80	40.64	8.60	21%	268.00	54%
Percentage of Individuals using the Internet	Other	INDPERINT	2000	2018	0.25	98.45	44.75	29.94	67%	35.00	7%
Physical and services infrastructure	Other	EFPSI	2000	2018	1.91	4.79	3.71	0.54	14%	223.00	45%

The DV covers an annual 20 year period from 1999 to 2018 and was operationalized as follows:

Description	Begin Yr	End Yr	Source
Total R&D as a percentage of GDP	1999	2018	UNESCO / UIS.Stat

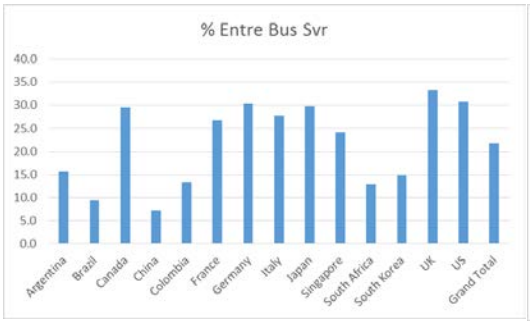
Use of the total expenditure as a percentage of GDP is an attempt to standardize the DV across countries. The below bar chart provides a visual representation of the variance between various countries in relation to their R&D expenditures:

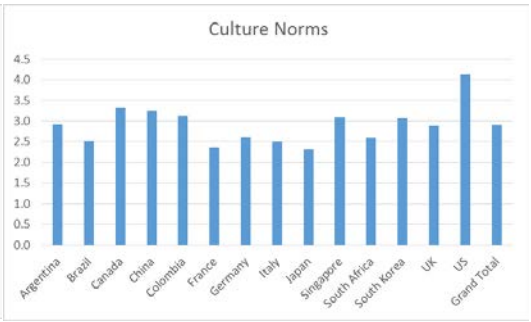


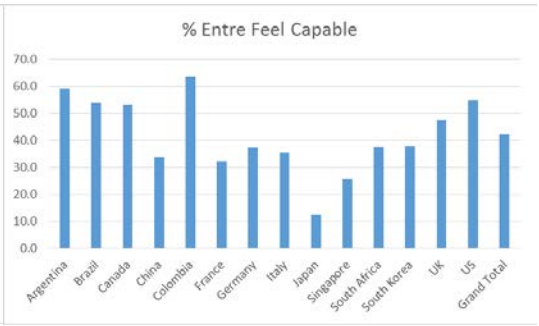
The degree of entrepreneurship was operationalized over several IVs:

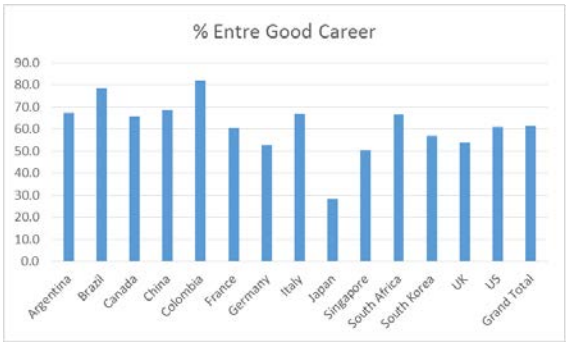
Description	Begin Yr	End Yr	Source
% Entrepreneurs in business services sector	2000	2018	GEM - Global Entrepreneurship Monitor
Cultural and social norms score	2000	2018	"
% of 18-64 year olds starting business fear failure	2000	2018	"
% of 18-64 population that perceived they are capable starting business	2000	2018	"
& of 18-64 population who agree entrepreneurship is a good career choice	2000	2018	"
Governmental entrepreneurial support and policies score	2000	2018	"
High Job Creation Expectation	2000	2018	"
Score ease of starting a business	2004	2018	World Bank

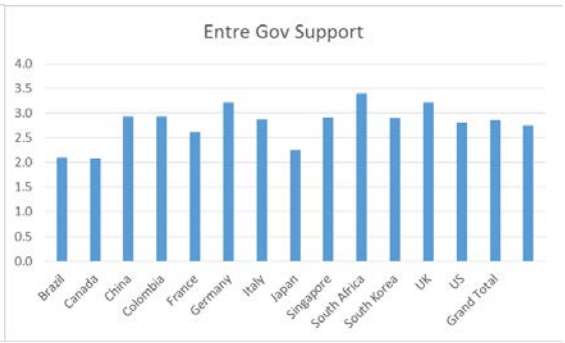
The below bar charts provide a visual representation of the variances between the different countries in relation to their entrepreneurial factors:

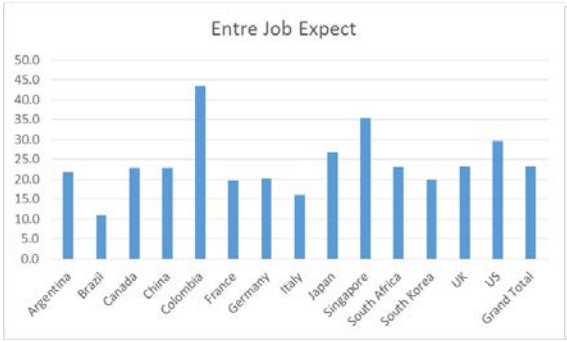


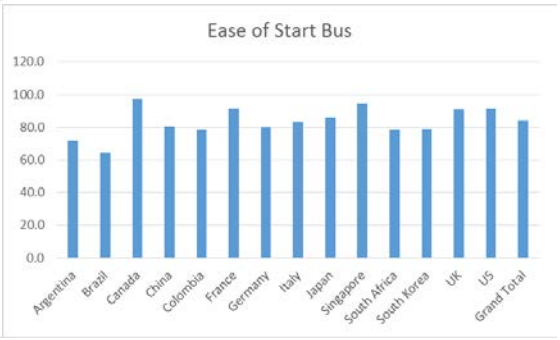










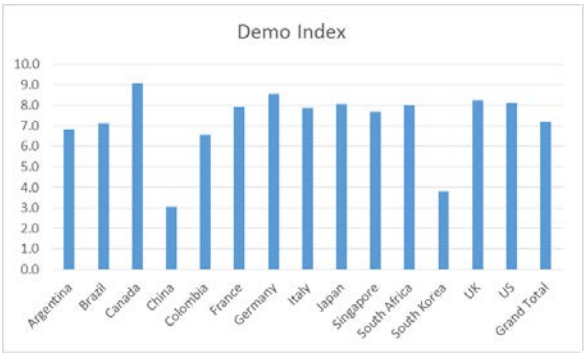


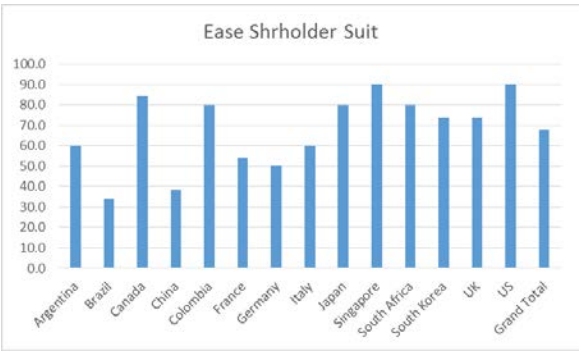
Visually there appears substantially variation between the countries with the exception, of, perhaps, the ease of starting a business IV.

The adequacy of legal structure was operationalized over the following two IVs:

Description	Begin Yr	End Yr	Source
Economist Intelligence Unit's Democracy Index	2006	2017	The Economist Intelligence Unit
Score-Ease of shareholder suits index (0-10)	2006	2018	World Bank

The below bar charts provide a visual representation of the variances between the different countries in relation to their legal structure:



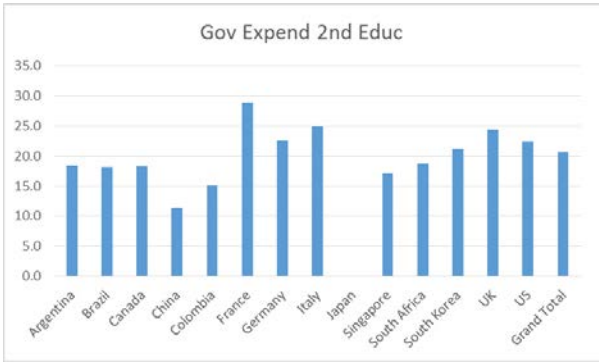


Visually these IVs appear to have reasonable variation between the countries.

Governmental support for education was operationalized using the following IV:

Description	Begin Yr	End Yr	Source
Government expenditure per student, secondary (% of GDP per capita)	1999	2018	UNESCO / World Bank

The below bar chart provide a visual representation of the variances between the different countries in relation to their government expenditure on secondary education:

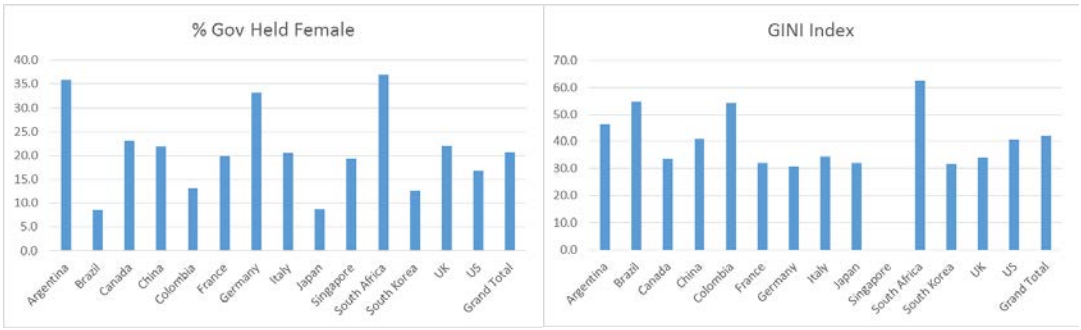


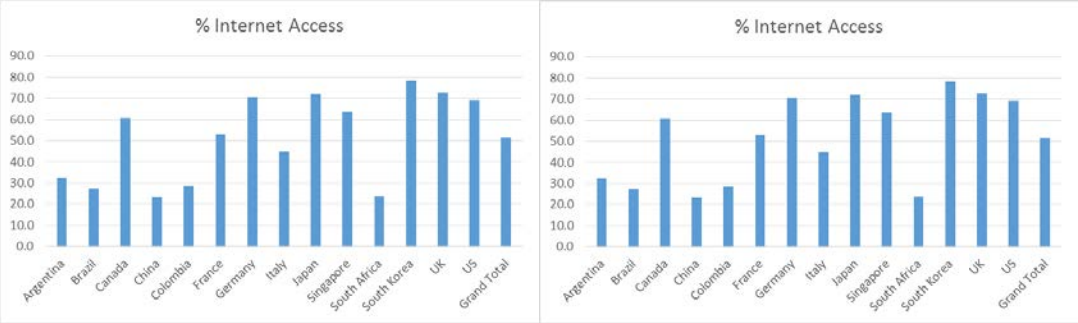
Visually this IV appears to have reasonable variation between countries.

Finally, a few other social dynamic variables of interest were included:

Description	Begin Yr	End Yr	Source
Proportion of seats held by women in national parliaments	1999	2018	Inter-Parliamentary Union (IPU) / World Bank
GINI index (World Bank estimate)	1999	2018	World Bank
Percentage of Individuals using the Internet	2000	2018	UN's International Telecommunication Union (ITU)
Physical and services infrastructure	2000	2018	GEM - Global Entrepreneurship Monitor

The below bar charts provide a visual representation of the variances between the different countries in relation to their other factors:





Again, variation appears reasonable across countries.

In order to evaluate the potential for multicollinearity, a correlation matrix was prepared.

Generally, a correlation of 70% to 80% should be of concern.

	% Entre Bus Svr	Culture Norms	% Entre fear failure	% Entre Feel Capable	% Entre Good Career	Entre Gov Support	Entre Job Expect	Ease of Start Bus	Demo Index	Ease Shrholder Suit	Gov Expend 2nd Educ	% Gov Held Female	GINI Index	% Internet Access	Infrastruc-ture
% Entre Bus Svr	100%														
Culture Norms	-6%	100%													
% Entre fear failure	30%	-61%	100%												
% Entre Feel Capable	-53%	64%	-80%	100%											
% Entre Good Career	-63%	13%	-26%	56%	100%										
Entre Gov Support	13%	22%	-4%	-17%	-14%	100%									
Entre Job Expect	-31%	58%	-54%	60%	50%	13%	100%								
Ease of Start Bus	58%	18%	21%	-33%	-30%	20%	17%	100%							
Demo Index	70%	-40%	49%	-81%	-73%	24%	-55%	44%	100%						
Ease Shrholder Suit	-11%	63%	-40%	41%	41%	13%	70%	48%	-33%	100%					
Gov Expend 2nd Educ	72%	-31%	38%	-52%	-68%	-6%	-63%	30%	66%	-42%	100%				
% Gov Held Female	1%	-25%	-3%	-30%	-48%	-8%	-45%	-32%	28%	-44%	18%	100%			
GINI Index	-75%	30%	-47%	60%	74%	-3%	61%	-32%	-69%	57%	-78%	-25%	100%		
% Internet Access	59%	7%	23%	-37%	-63%	21%	-20%	54%	56%	-16%	53%	4%	-65%	100%	
Infrastructure	33%	41%	-25%	11%	-45%	17%	9%	28%	27%	-1%	16%	13%	-36%	49%	100%

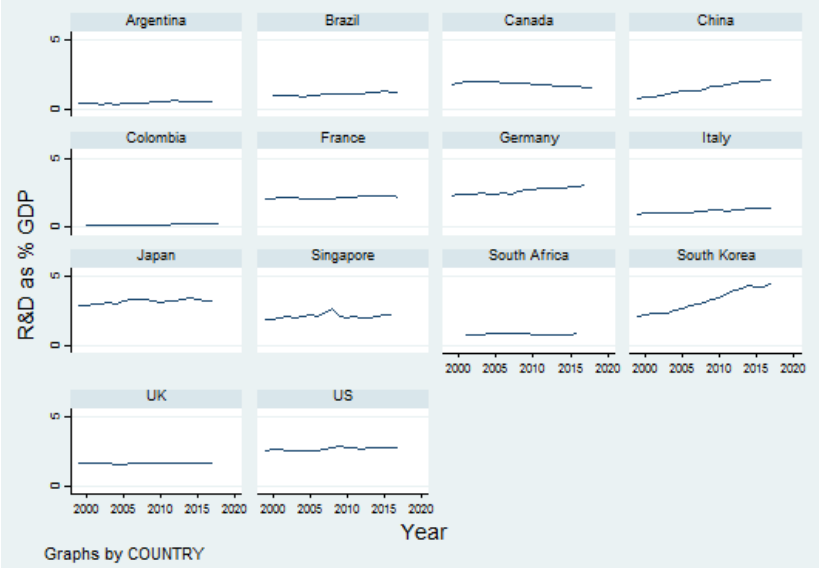
There are a few variables creating concern, namely:

% Entre Feel Capable	vs.	% Entre fear failure						
Demo Index	vs.	% Entre Bus Svr	vs.	% Entre Feel Capable	vs.	% Entre Good Career		
Ease Shrholder Suit	vs.	Entre Job Expect						
Gov Expend 2nd Educ	vs.	% Entre Bus Svr						
GINI Index	vs.	% Entre Bus Svr	vs.	% Entre Good Career	vs.	Demo Index	vs.	Gov Expend 2nd Educ

Multicollinearity can cause estimators to change significantly depending upon which IVs are included or excluded from the model. That is, they become sensitive to model specifications. Multicollinearity also reduces the precision of the estimators creating

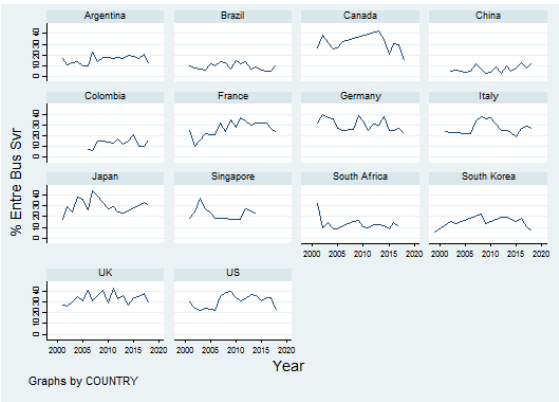
difficulty in evaluating their statistical significance. Therefore, these issues will be monitored during model development.

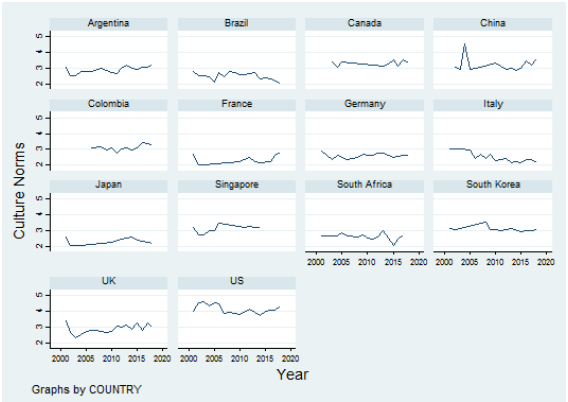
To visually examine serial correlation in the DV the following graphic was prepared:

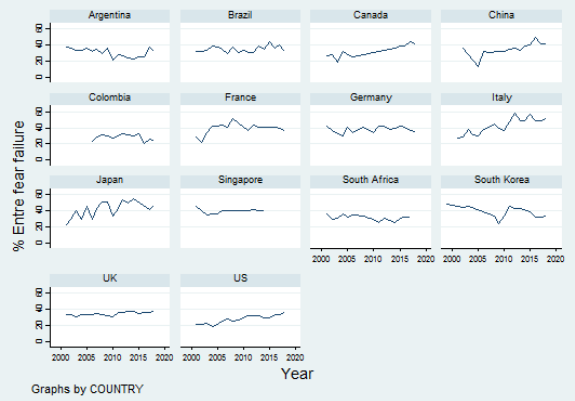


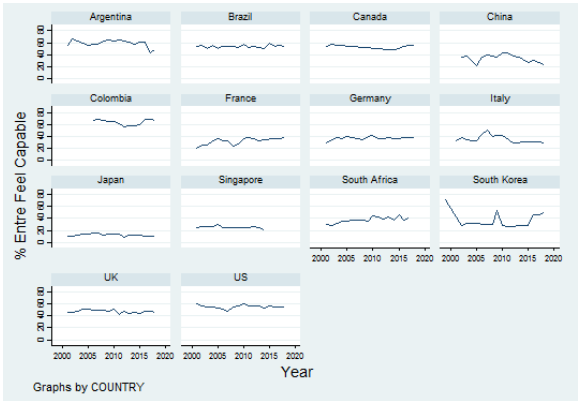
With the exception of South Korea there appears to be little trending in the DV.

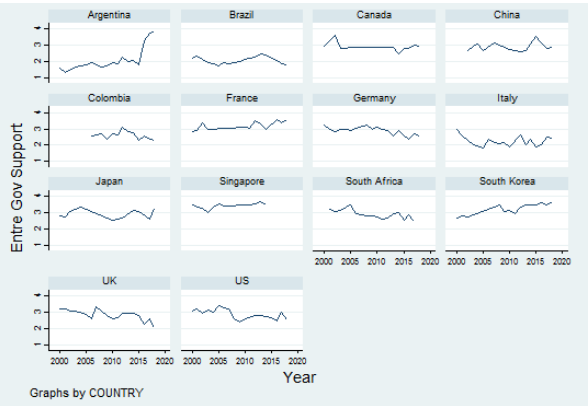
To examine serial correlation in the entrepreneurial IVs the following graphics were prepared:

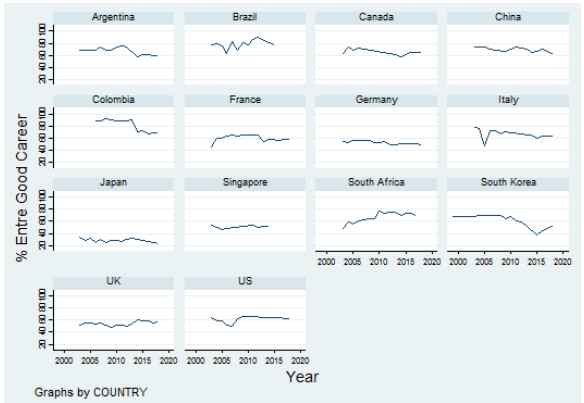


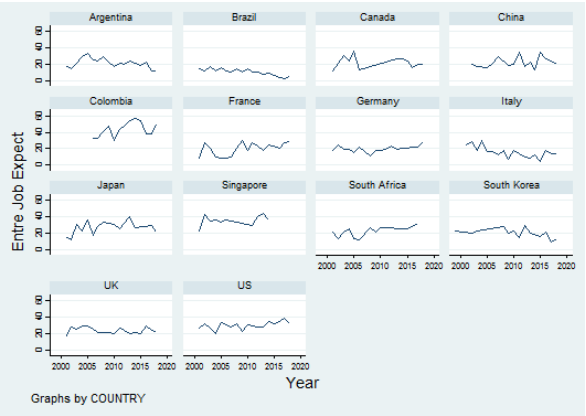


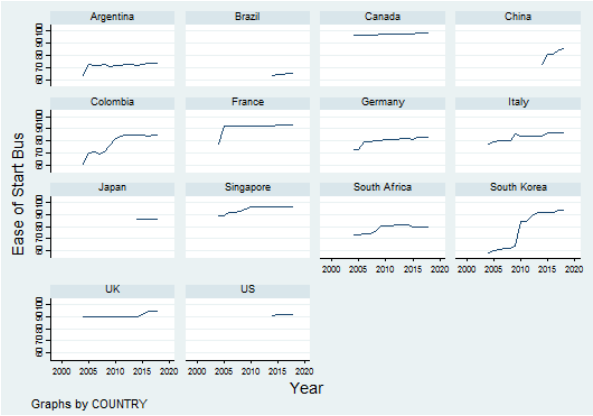






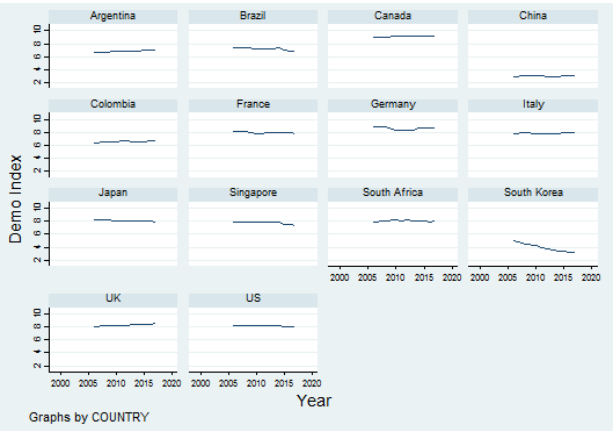


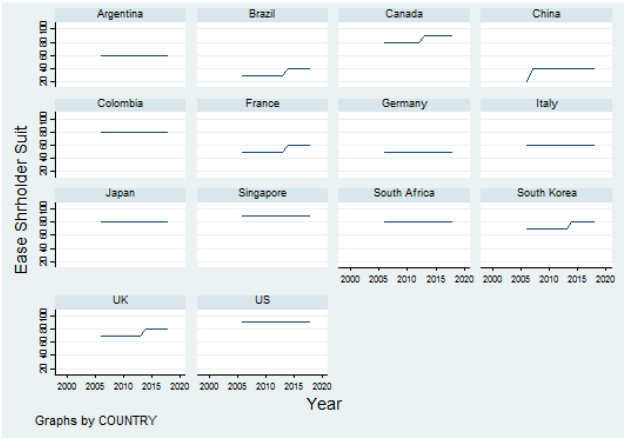


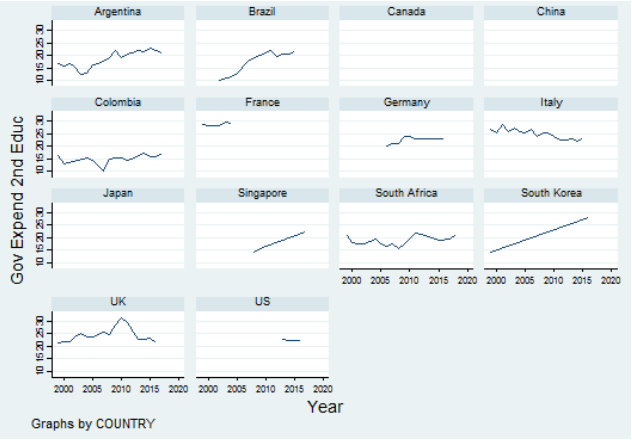


Here again, with few exceptions there appears to be little trending in the entrepreneurial IVs.

To evaluate trending in the legal factors the following graphics were prepared:

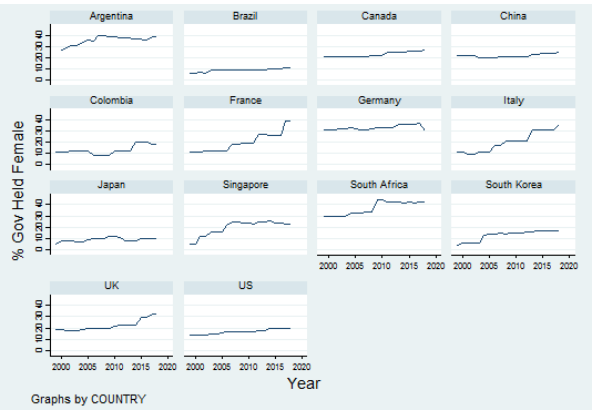


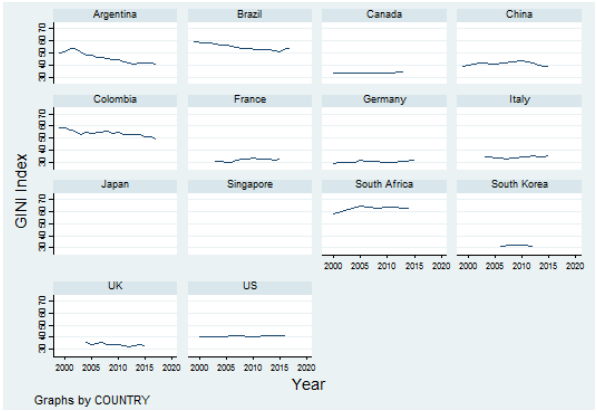


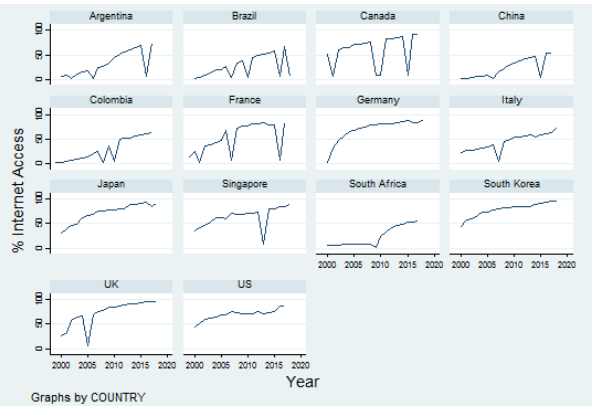


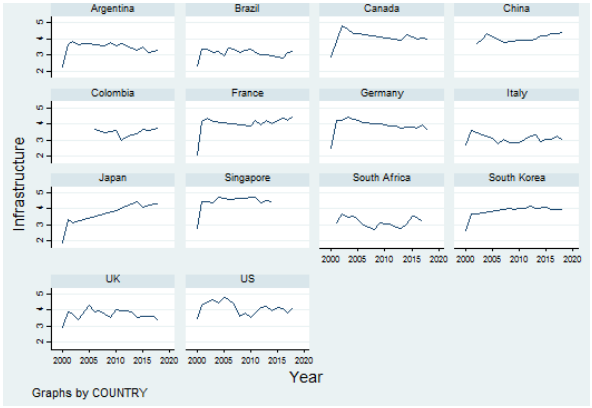
Visually there is little trend in the democratic index IV or the ease of shareholder suit score IV. The government expenditure on secondary education IV may have some indicated positive trending.

To evaluate serial correlation in the other factors the following graphics were prepared:









Here there appears to be some trending in the percentage of internet access but overall there is little serial correlation in the other IV group.

Model Specifications

Two models will be developed as panel data models with a 14 country (N = 14) unit count, span of 20 years (T = 20), and delta of 1 years. The first is a fixed effects model with the following format:

$$RD_{it} = \alpha_1 + \alpha_2 D_{2i} \ldots + \alpha_{N-1} D_{Ni} + \beta_{2i} EF + \beta_{3i} LF + \beta_{4i} GE + \beta_{5i} OF + u_{it}$$

The second model is a random effects model with the following format:

$$RD_{it} = \beta_1 + \beta_{2i} EF + \beta_{3i} LF + \beta_{4i} GE + \beta_{5i} OF + w_{it}$$

and $w_{it} = \epsilon_i + u_{it}$

Where:

i = 1, …., N
t = 1, …, T
RD = R&D percent of GDP
EF = Entrepreneurial Factors
LF = Legal Factors
GE = Government Support Education
OF = Other Factors
D = Country dummy variable
Є = individual-specific country or unit error
u = time series cross sectional or idiosyncratic error

Model Fit and Comparisons / Estimations

Four separate models were evaluated, each under both the fixed effects and random effects specifications. These included:

1) All Variables – Model included all variables.
2) Removal of Highly Correlated Variables – Model excluded previously identified highly correlated variables.
3) Potential Variables – Model included only those variables that appeared possibly correlated with the dependent variable.

4) Viable Variables – Model included only those statistically significant from previous Potential Variables model.

Below is the data generated from these models:

Table of Total R&D as Percent of GDP Model Output

Dependent Variable: Total R&D as a Percent of GDP

		Model Name:	All Variables		Removed Highly Correlated		Potential Variable		Viable Variables	
		Model Effects Type:	Fixed	Random	Fixed	Random	Fixed	Random	Fixed	Random
Independent Variable Description	**Variable Name**	**Stat Description**								
% Entrepreneurs in business services sector	EFBSS	Coefficient	0.0008	-0.0070						
		SE	0.0037	0.0109						
		P-value	0.8223	0.5227						
Cultural and social norms score	EFCSN	Coefficient	-0.0646	1.0567	-0.0111	-0.1848	-0.0216	-0.0357		
		SE	0.1241	0.2703	0.0807	0.3501	0.0626	0.0637		
		P-value	0.6094	0.0001 **	0.8915	0.5977	0.7300	0.5750		
% of 18-64 year olds starting business fear failure	EFFF	Coefficient	0.0078	0.0099	0.0079	0.0242	0.0076	0.0079	0.0052	0.0054
		SE	0.0053	0.0155	0.0029	0.0181	0.0025	0.0025	0.0023	0.0024
		P-value	0.1620	0.5200	0.0113 *	0.1823	0.0030 **	0.0020 **	0.0260 *	0.0220 *
% of 18-64 population perceived they are capable starting business	EFPC	Coefficient	-0.0005	-0.0061						
		SE	0.0072	0.0181						
		P-value	0.9417	0.7386						
% of 18-64 population agree entrepreneurship good career choice	EFGCC	Coefficient	-0.0009	0.0095	-0.0032	-0.0245				
		SE	0.0030	0.0083	0.0022	0.0145				
		P-value	0.7589	0.2510	0.1642	0.0913				
Governmental entrepreneurial support and policies score	EFGSP	Coefficient	-0.0763	-0.2044	-0.0718	0.3951				
		SE	0.0661	0.1293	0.0400	0.2099				
		P-value	0.2649	0.1139	0.0831	0.0597				
High Job Creation Expectation	EFJCE	Coefficient	-0.0039	0.0111	-0.0035	-0.0033				
		SE	0.0029	0.0069	0.0023	0.0130				
		P-value	0.1901	0.1075	0.1393	0.8003				
Score-Starting a business	STARTBUSSCR	Coefficient	-0.0046	0.0061	-0.0045	0.0051				
		SE	0.0082	0.0200	0.0071	0.0328				
		P-value	0.5868	0.7589	0.5313	0.8759				
Economist Intelligence Unit's Democracy Index	DEMINDX	Coefficient	-0.2337	1.1316	-0.1978	-0.0078	-0.4869	-0.4255	-0.4696	-0.4187
		SE	0.1435	0.1628	0.1086	0.1094	0.0677	0.0624	0.0680	0.0629
		P-value	0.1217	0.0000 **	0.0788	0.9432	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***
Score-Ease of shareholder suits index (0-10)	MINSUITSCR	Coefficient	-0.0020	-0.0430	-0.0007	-0.0024	0.0124	0.0140	0.0155	0.0162
		SE	0.0105	0.0126	0.0081	0.0157	0.0041	0.0040	0.0034	0.0033
		P-value	0.8541	0.0006 **	0.9322	0.8788	0.0030 ***	0.0000 ***	0.0000 ***	0.0000 ***
Gov expenditure per student, secondary (% of GDP per capita)	GOVEXPSEC	Coefficient	0.0050	-0.0023	0.0052	0.0423				
		SE	0.0095	0.0228	0.0076	0.0395				
		P-value	0.6026	0.9193	0.4981	0.2839				
Proportion of seats held by women in national parliaments (%)	FMPAR	Coefficient	0.0085	-0.0061	0.0062	-0.0027				
		SE	0.0061	0.0089	0.0051	0.0132				
		P-value	0.1805	0.4953	0.2392	0.8382				
GINI index (World Bank estimate)	GINI	Coefficient	-0.0219	0.0065						
		SE	0.0260	0.0140						
		P-value	0.4126	0.6403						
Percentage of Individuals using the Internet	INDPERINT	Coefficient	0.0003	0.0026	0.0012	0.0044				
		SE	0.0017	0.0029	0.0009	0.0059				
		P-value	0.8792	0.3712	0.2093	0.4530				
Physical and services infrastructure	EFPSI	Coefficient	-0.1731	0.2090	-0.1758	0.8179	-0.0136	0.0042		
		SE	0.0954	0.1922	0.0736	0.3305	0.0554	0.0566		
		P-value	0.0872	0.2769	0.0237 *	0.0133 *	0.8070	0.9400		
Constant	_cons	Coefficient	4.8731	-9.1579	3.7593	-2.4341	4.2841	3.7914	3.9903	3.6029
		SE	2.6247	2.9446	1.3421	3.1394	0.6762	0.6827	0.5729	0.5929
		P-value	0.0808	0.0019 **	0.0090 **	0.4381	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***
Model Specific Statistics										
N			40	40	50	50	112	112	123	123
Chi2 - Stat				0.0000		0.0000		0.0000		0.0000
F - Stat			0.2137		0.0157		0.0000		0.0000	
R2			0.5678		0.5231		0.5061		0.4605	
Hausmann's Prob>chi2 =			0.0021		0.0000		0.0516		0.0688	
suggesting best fix:			Fixed Effects		Fixed Effects		Random Effects		Random Effects	

P-value is less than 0.05 (*); P-value is less than 0.01 (**); P-value is less than 0.001 (***)

Analyzing the final results suggest the following equation:

$$RD = 3.6 + .005 \text{ Fear of Failure} - .42 \text{ Degree of Democray} + .016 \text{ Ease of Sharehold Suits}$$

Only one of these variables have a coefficient in the correction direction, namely the ease of shareholder suits. It seems reasonable that the greater the ease of that shareholders have in taking action against companies the more likely they are to invest in companies that develop new ideas through R&D. However, the model indicates that the greater the degree a country is democratic the less likely it will invest in R&D. This seems counter intuitive. Additionally, the model indicates the greater an entrepreneur fears failure the more R&D will increase. Again this seems counter intuitive.

An additionally analysis, similar to the above, was performed by lagging the DV one period and including that variable as a regressor. This analysis produced similarly poor results. See appendix B for the output from these models.

Conclusion

Give that this approach did not produce fruitful results it must be reconsidered. Perhaps the overall approach to analyzing R&D expenditures in terms of a country's entrepreneurship, legal structure, and support for education is incorrect. Perhaps there is a problem associated with the countries selected. Perhaps new DVs or IVs might be analyzed in pursuant of this end. However, these conclusions do assist future researchers as they demonstrate that the path taken here was unfruitful.

Appendix A - Data Sources

Below is the table of data sources:

Variable Description	Source	Source Link
Total R&D as a percentage of GDP	UNESCO / UIS.Stat	https://en.unesco.org/
% Entrepreneurs in business services sector	GEM - Global Entrepreneurship Monitor	https://www.gemconsortium.org/data/key-aps
Cultural and social norms score	GEM - Global Entrepreneurship Monitor	https://www.gemconsortium.org/data/key-aps
% of 18-64 year olds starting business fear failure	GEM - Global Entrepreneurship Monitor	https://www.gemconsortium.org/data/key-aps
% of 18-64 population that perceived they are capable starting business	GEM - Global Entrepreneurship Monitor	https://www.gemconsortium.org/data/key-aps
& of 18-64 population who agree entrepreneurship is a good career choice	GEM - Global Entrepreneurship Monitor	https://www.gemconsortium.org/data/key-aps
Governmental entrepreneurial support and policies score	GEM - Global Entrepreneurship Monitor	https://www.gemconsortium.org/data/key-aps
High Job Creation Expectation	GEM - Global Entrepreneurship Monitor	https://www.gemconsortium.org/data/key-aps
Score ease of starting a business	World Bank	https://datacatalog.worldbank.org/public-licenses#cc-by
Economist Intelligence Unit's Democracy Index	The Economist Intelligence Unit	https://infographics.economist.com/2018/DemocracyIndex/
Score-Ease of shareholder suits index (0-10)	World Bank	https://datacatalog.worldbank.org/public-licenses#cc-by
Gov expenditure per student, secondary (% of GDP per capita)	UNESCO / World Bank	http://uis.unesco.org/
Proportion of seats held by women in national parliaments (%)	Inter-Parliamentary Union (IPU) / World Bank	www.ipu.org
GINI index (World Bank estimate)	World Bank	https://datacatalog.worldbank.org/public-licenses#cc-by
Percentage of Individuals using the Internet	UN's International Telecommunication Union (ITU)	https://www.itu.int/en/ITU-D/Pages/default.aspx
Physical and services infrastructure	GEM - Global Entrepreneurship Monitor	https://www.gemconsortium.org/data/key-aps

Appendix B – Supplemental Lagged Variable Analysis

Table of Total R&D as Percent of GDP with One Period Lagged Model Output

Dependent Variable: Total R&D as a Percent of GDP

	Model Name:	All Variables		emoved Highly Correlate Potential Variable				Viable Variables	
	Model Effects Type:	Fixed	Random	Fixed	Random	Fixed	Random	Fixed	Random
Independent Variable Description	**Stat Description**								
% Entrepreneurs in business services sector	Coefficient	-0.0020	-0.0014						
	SE	0.0018	0.0015						
	P-value	0.2794	0.3676						
Cultural and social norms score	Coefficient	-0.0006	0.0467	0.0015	-0.0222	-0.0394	-0.0053		
	SE	0.0590	0.0467	0.0364	0.0209	0.0335	0.0187		
	P-value	0.9923	0.3180	0.9667	0.2882	0.2426	0.7786		
% of 18-64 year olds starting business fear failure	Coefficient	0.0016	0.0013	0.0031	0.0023	0.0029	0.0009	0.0018	0.0009
	SE	0.0026	0.0021	0.0014	0.0011	0.0014	0.0011	0.0012	0.0009
	P-value	0.5640	0.5505	0.0328	0.0334	0.0341	0.4321	0.1223	0.3465
% of 18-64 population perceived they are capable starting business	Coefficient	-0.0029	-0.0021						
	SE	0.0034	0.0025						
	P-value	0.4070	0.4094						
% of 18-64 population agree entrepreneurship good career choice	Coefficient	0.0014	0.0014	0.0002	0.0005				
	SE	0.0015	0.0012	0.0010	0.0009				
	P-value	0.3467	0.2165	0.8513	0.5407				
Governmental entrepreneurial support and policies score	Coefficient	-0.0285	-0.0181	-0.0084	0.0051				
	SE	0.0318	0.0185	0.0190	0.0131				
	P-value	0.3825	0.3268	0.6629	0.6939				
High Job Creation Expectation	Coefficient	0.0007	0.0007	0.0002	-0.0001				
	SE	0.0015	0.0010	0.0011	0.0008				
	P-value	0.6635	0.4571	0.8527	0.8628				
Score-Starting a business	Coefficient	-0.0024	-0.0043	-0.0013	-0.0032				
	SE	0.0039	0.0028	0.0032	0.0020				
	P-value	0.5485	0.1193	0.6778	0.1042				
Economist Intelligence Unit's Democracy Index	Coefficient	-0.0034	0.0507	-0.0184	0.0065	-0.0634	-0.0168	-0.0475	-0.0154
	SE	0.0738	0.0378	0.0517	0.0065	0.0456	0.0048	0.0407	0.0042
	P-value	0.9639	0.1802	0.7241	0.3213	0.1676	0.0005	0.2462	0.0003
Score-Ease of shareholder suits index (0-10)	Coefficient	-0.0023	-0.0006	0.0007	0.0007	0.0004	0.0001	0.0009	0.0000
	SE	0.0049	0.0021	0.0037	0.0009	0.0023	0.0005	0.0018	0.0004
	P-value	0.6541	0.7732	0.8425	0.4326	0.8783	0.9033	0.6426	0.9917
Gov expenditure per student, secondary (% of GDP per capita)	Coefficient	-0.0048	-0.0029	-0.0032	-0.0016				
	SE	0.0047	0.0031	0.0035	0.0024				
	P-value	0.3162	0.3610	0.3615	0.5002				
Proportion of seats held by women in national parliaments (%)	Coefficient	-0.0028	-0.0025	-0.0031	-0.0014				
	SE	0.0032	0.0012	0.0025	0.0008				
	P-value	0.3930	0.0425	0.2221	0.0856				
GINI index (World Bank estimate)	Coefficient	-0.0119	-0.0029						
	SE	0.0123	0.0019						
	P-value	0.3487	0.1392						
Percentage of Individuals using the Internet	Coefficient	0.0001	0.0004	0.0008	0.0004				
	SE	0.0008	0.0004	0.0004	0.0004				
	P-value	0.8734	0.3182	0.0583	0.2151				
Physical and services infrastructure	Coefficient	0.0135	0.0415	0.0231	0.0383	0.0096	-0.0070		
	SE	0.0509	0.0268	0.0380	0.0211	0.0297	0.0192		
	P-value	0.7938	0.1212	0.5478	0.0697	0.7475	0.7134		
Constant	Coefficient	1.2645	0.0264	0.3614	0.0170	0.7633	0.1216	0.5212	0.0750
	SE	1.3203	0.4796	0.6825	0.1884	0.4286	0.0841	0.3405	0.0448
	P-value	0.3525	0.9561	0.6006	0.9279	0.0783	0.1484	0.1288	0.0945
Lagged - Total R&D as a Percent of GDP	Coefficient	0.8577	0.9683	0.8285	1.0058	0.8091	1.0166	0.8470	1.0170
	SE	0.1102	0.0273	0.0773	0.0099	0.0529	0.0093	0.0465	0.0071
	P-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Model Specific Statistics								
N	40	40	50	50	112	112	123	123
Chi2 - Stat		0.0000		0.0000		0.0000		0.0000
F - Stat	0.0000		0.0000		0.0000		0.0000	
R2	0.9098		0.9066		0.8604		0.8703	
Hausmann's Prob>chi2 =	0.0021		0.0000		0.0516		0.0688	
suggesting best fix:	Fixed Effects		Fixed Effects		Random Effects		Random Effects	

Appendix C – Stata Code

Below is the Stata code used in the development of this paper.

```
/*      Exploration of Factors Leading to National R&D Expenditures */
/*
        List of Variables Used in this Code:
Variable        Variable Description
RDPERGDP        Total R&D as a Percent of GDP
EFBSS           % Entrepreneurs in business services sector
EFCSN           Cultural and social norms score
EFFF            % of 18-64 year olds starting business fear failure
EFPC            % of 18-64 population perceived they are capable starting business
EFGCC           % of 18-64 population agree entrepreneurship good career choice
EFGSP           Governmental entrepreneurial support and policies score
EFJCE           High Job Creation Expectation
STARTBUSSCR     Score-Starting a business
DEMINDX         Economist Intelligence Unit's Democracy Index
MINSUITSCR      Score-Ease of shareholder suits index (0-10)
GOVEXPSEC       Gov expenditure per student, secondary (% of GDP per capita)
FMPAR           Proportion of seats held by women in national parliaments (%)
GINI            GINI index (World Bank estimate)
INDPERINT       Percentage of Individuals using the Internet
EFPSI           Physical and services infrastructure  */

/*                      Initial setup */
/* Establish data as Panel Data */
xtset COUNTRY_NM YEAR, YEARPANEL

/*                  Examine Data                    */
/* Describe the data */
xtdes
desc
/* Correlation Analysis */
corr(EFBSS EFCSN EFFF EFPC EFGCC EFGSP EFJCE STARTBUSSCR ///
    DEMINDX MINSUITSCR ///
        GOVEXPSEC ///
        FMPAR GINI INDPERINT EFPSI)
/* Serial Correlation Graphics */
/* DV */
twoway (line RDPERGDP YEAR_NM), ytitle("R&D as % GDP") xtitle("Year") ///
      by(COUNTRY)
/* IVs Entrepreneurial Factors */
```

```
twoway (line EFBSS YEAR_NM), ytitle("% Entre Bus Svr") xtitle("Year") ///
      by(COUNTRY)
twoway (line EFCSN YEAR_NM), ytitle("Culture Norms") xtitle("Year") ///
      by(COUNTRY)
twoway (line EFFF YEAR_NM), ytitle("% Entre fear failure") xtitle("Year") ///
      by(COUNTRY)
twoway (line EFPC YEAR_NM), ytitle("% Entre Feel Capable") xtitle("Year") ///
      by(COUNTRY)
twoway (line EFGCC YEAR_NM), ytitle("% Entre Good Career") xtitle("Year") ///
      by(COUNTRY)
twoway (line EFGSP YEAR_NM), ytitle("Entre Gov Support") xtitle("Year") ///
      by(COUNTRY)
twoway (line EFJCE YEAR_NM), ytitle("Entre Job Expect") xtitle("Year") ///
      by(COUNTRY)
twoway (line STARTBUSSCR YEAR_NM), ytitle("Ease of Start Bus") xtitle("Year")///
      by(COUNTRY)
/* IVs Legal Factors */
twoway (line DEMINDX YEAR_NM), ytitle("Demo Index") xtitle("Year") ///
     by(COUNTRY)
twoway (line MINSUITSCR YEAR_NM), ytitle("Ease Shrholder Suit") xtitle("Year")///
     by(COUNTRY)
/* IV Government Support Educ */
twoway (line GOVEXPSEC YEAR_NM), ytitle("Gov Expend 2nd Educ") xtitle("Year")///
     by(COUNTRY)
/* IV Other */
twoway (line FMPAR YEAR_NM), ytitle("% Gov Held Female") xtitle("Year") ///
     by(COUNTRY)
twoway (line GINI YEAR_NM), ytitle("GINI Index") xtitle("Year") ///
     by(COUNTRY)
twoway (line INDPERINT YEAR_NM), ytitle("% Internet Access") xtitle("Year") ///
     by(COUNTRY)
twoway (line EFPSI YEAR_NM), ytitle("Infrastructure") xtitle("Year") ///
     by(COUNTRY)



/*              TOTAL RD ANALYSIS - RDPERGDP          */
/* Set More Off */
set more off
/*              Model All Variables         */
/*        Fixed Effects Model All Variables  */
xtreg RDPERGDP EFBSS EFCSN EFFF EFPC EFGCC EFGSP EFJCE STARTBUSSCR ///
    DEMINDX MINSUITSCR ///
        GOVEXPSEC ///
        FMPAR GINI INDPERINT EFPSI, fe
est store FEALLVAR

/*        Random Effects Model All Variables  */
```

```
xtreg RDPERGDP EFBSS EFCSN EFFF EFPC EFGCC EFGSP EFJCE STARTBUSSCR ///
    DEMINDX MINSUITSCR ///
        GOVEXPSEC ///
        FMPAR GINI INDPERINT EFPSI, re
est store REALLVAR

/*       Removing Highly Correlated Variables
            i.e. GINI EFBSS EFPC          */
/*    Fixed Effects Removing Highly Correlated Variables  */
xtreg RDPERGDP EFCSN EFFF EFGCC EFGSP EFJCE STARTBUSSCR ///
    DEMINDX MINSUITSCR ///
        GOVEXPSEC ///
        FMPAR INDPERINT EFPSI, fe
est store FERMCORVA
/*    Random Effect Removing Highly Correlated Variables */
xtreg RDPERGDP EFCSN EFFF EFGCC EFGSP EFJCE STARTBUSSCR ///
    DEMINDX MINSUITSCR ///
        GOVEXPSEC ///
        FMPAR INDPERINT EFPSI, re
est store RERMCORVA

/*       Potential Viable Variables Only
  i.e. excluding EFBSS EFJCE EFPC EFGCC EFGSP STARTBUSSCR GOVEXPSEC
            GINI FMPAR INDPERINT                */
/* Fixed Effects Potential Viable Variables     */
xtreg RDPERGDP EFCSN EFFF  ///
    DEMINDX MINSUITSCR ///
         EFPSI, fe
est store FEPOTVAR
/* Random Effects Potential Viable Variables */
xtreg RDPERGDP EFCSN EFFF ///
    DEMINDX MINSUITSCR ///
        EFPSI, re
est store REPOTVAR

/*            Only Viable Variables
i.e. excluding EFBSS FPC EFGCC EFGSP STARTBUSSCR GOVEXPSEC GINI FMPAR
           INDPERINT RDPERGDP EFCSN EFJCE EFPSI */
/* Fixed Effects Only Viable Variables  */
xtreg RDPERGDP EFFF DEMINDX MINSUITSCR, fe
est store FEONLYVAR
/* Random Effects Only Viable Variables */
xtreg RDPERGDP EFFF DEMINDX MINSUITSCR, re
est store REONLYVAR

/* Produce Summary Table All Regressions */
est table FEALLVAR REALLVAR FERMCORVA RERMCORVA ///
       FEPOTVAR REPOTVAR FEONLYVAR REONLYVAR, ///
```

```
                se p stats(N chi2 F r2)

/* Hausmann Test All Regression Pairs  */
hausman FEALLVAR REALLVAR, sigmamore
hausman FERMCORVA RERMCORVA, sigmamore
hausman FEPOTVAR REPOTVAR, sigmamore
hausman FEONLYVAR REONLYVAR, sigmamore

/* Set More On */
set more on


/*            TOTAL RD ANALYSIS Lagged - RDPERGDP          */
/* Set More Off */
set more off
/*             Lagged Model All Variables         */
/*       Fixed Effects Model All Variables  */
xtreg RDPERGDP l.RDPERGDP EFBSS EFCSN EFFF EFPC EFGCC EFGSP EFJCE STARTBUSSCR ///
    DEMINDX MINSUITSCR ///
       GOVEXPSEC ///
       FMPAR GINI INDPERINT EFPSI, fe
est store LFEALLVAR

/*       Random Effects Model All Variables  */
xtreg RDPERGDP l.RDPERGDP EFBSS EFCSN EFFF EFPC EFGCC EFGSP EFJCE STARTBUSSCR ///
    DEMINDX MINSUITSCR ///
       GOVEXPSEC ///
       FMPAR GINI INDPERINT EFPSI, re
est store LREALLVAR
/*       Lagged Removing Highly Correlated Variables
           i.e. GINI EFBSS EFPC          */
/*    Fixed Effects Removing Highly Correlated Variables  */
xtreg RDPERGDP l.RDPERGDP EFCSN EFFF EFGCC EFGSP EFJCE STARTBUSSCR ///
    DEMINDX MINSUITSCR ///
       GOVEXPSEC ///
       FMPAR INDPERINT EFPSI, fe
est store LFERMCORVA
/*    Random Effect Removing Highly Correlated Variables */
xtreg RDPERGDP l.RDPERGDP EFCSN EFFF EFGCC EFGSP EFJCE STARTBUSSCR ///
    DEMINDX MINSUITSCR ///
       GOVEXPSEC ///
       FMPAR INDPERINT EFPSI, re
est store LRERMCORVA

/*       Lagged Potential Viable Variables Only
  i.e. excluding EFBSS EFJCE EFPC EFGCC EFGSP STARTBUSSCR GOVEXPSEC
            GINI FMPAR INDPERINT                */
/* Fixed Effects Potential Viable Variables     */
```

```
xtreg RDPERGDP l.RDPERGDP EFCSN EFFF  ///
    DEMINDX MINSUITSCR ///
        EFPSI, fe
est store LFEPOTVAR
/* Random Effects Potential Viable Variables */
xtreg RDPERGDP l.RDPERGDP EFCSN EFFF ///
    DEMINDX MINSUITSCR ///
        EFPSI, re
est store LREPOTVAR

/*          Lagged Only Viable Variables
i.e. excluding EFBSS FPC EFGCC EFGSP STARTBUSSCR GOVEXPSEC GINI FMPAR
           INDPERINT RDPERGDP EFCSN EFJCE EFPSI */
/* Fixed Effects Only Viable Variables  */
xtreg RDPERGDP l.RDPERGDP EFFF DEMINDX MINSUITSCR, fe
est store LFEONLYVAR
/* Random Effects Only Viable Variables */
xtreg RDPERGDP l.RDPERGDP EFFF DEMINDX MINSUITSCR, re
est store LREONLYVAR

/* Produce Summary Table All Regressions */
est table LFEALLVAR LREALLVAR LFERMCORVA LRERMCORVA ///
       LFEPOTVAR LREPOTVAR LFEONLYVAR LREONLYVAR, ///
                se p stats(N chi2 F r2)

/* Hausmann Test All Regression Pairs  */
hausman LFEALLVAR LREALLVAR, sigmamore
hausman LFERMCORVA LRERMCORVA, sigmamore
hausman LFEPOTVAR LREPOTVAR, sigmamore
hausman LFEONLYVAR LREONLYVAR, sigmamore

/* Set More On */
set more on
```