Further Refinements and Developments of ACMD Economic Model

Further Development of the Model

Iteration 1 of Prototype

We now set out the initial iteration of the model, and its conceptual framework.[i]

We model productivity as a function of factors which have a direct impact on productivity in a country. These factors are themselves influenced by the policy decisions of a country. The factors affecting productivity are: stock of foreign direct investment, stock of capital provided by the financial sector, health expenditures, and human capital stock per worker. However, fuel exports, and ore and metal exports need to be considered as these could distort a nation's productivity particularly if it relies on them unduly. Health expenditures may be a weak proxy for health outcomes, and in future work other proxies might be used. The policy decisions are captured using our three indicators: Property Rights Protection, Domestic Competition, and International Competition. The structure of the estimation and the results are described below Productivity is measured in terms of GDP per capita. We estimate a reduced-form model to determine the factors which affect productivity. These factors are themselves influenced by the scores for Domestic Competition, International Competition, and Property Rights Protection. Our productivity model is:

log(GDP/Capita) = β0 + β1 ∗log(FDI stock) + β2 ∗Health Expend./Capita + β3 ∗Domestic Credit stock + β4 ∗Human Capital stock + β5 ∗Fuel Exports + β6 ∗Ore + Metal Exports + (1)

The log of FDI stock variable is the logarithm of the stock of Foreign Direct Investment per capita in a given country in a given year[ii] and represents the stock of foreign capital available to each person in a given country in a given year. The health expenditures per cap variable is a dollar value per person spent on healthcare in a country in a given year and it captures the influence of overall health in a country. Domestic credit stock is measured as the value of credit provided in an economy by its own financial sector and is reported as a percentage of GDP. This captures the available credit in an economy from its own financial sector. Human Capital Stock per Worker is an aggregate measure of the human capital stock within a country, assuming imperfect substitutability between skilled and unskilled workers[iii]. This measure is based on educational factors but is more sophisticated than a measure that merely uses enrolment ratios or educational attainment[iv]. Fuel exports and Ore and Metal exports[v] are both reported as percentages of total merchandise exports and are both controls for differences in productivity which arise from the existence of natural resources within a country.

We will now discuss the factors directly affecting productivity and how the Property Rights Protection, Domestic Competition, and International Competition scores influence these factors.

Stock of FDI

One measure of capital is log of FDI stock. This measure captures the amount of foreign money that has come into a country and how that money is spread cross the population on average. The stock of FDI is used instead of the change in FDI because the stock essentially tells us the amount of foreign money available to the average individual. Current flows, on the other hand, will slow down once the stock reaches a certain threshold and pick up if the stock starts to dwindle. The stock of FDI also reflects the openness of an economy. If trade is truly allowed to flow freely in and out of a country, then the FDI stock will be higher because the costs associated with investing will be reduced. FDI brings, "needed capital, skills, and know-how, either producing goods needed for the domestic market or contributing new exports."[vi] Thus, FDI falls into the Solow critique category of proximate causes for economic growth through the capital factor.

Property rights play a significant role in the inflow of FDI. The positive relationship between property rights and FDI is due in large part to the roles played by intellectual property rights protection and protection from expropriation. The strength of intellectual property rights protection has a positive effect on FDI inflows[vii] since greater intellectual property rights protection attracts investment in innovative technology[viii]. Ensuring that property will not be expropriated is a necessary insurance for foreign entities considering investing in a country[ix]. One of the reasons FDI is so low in developing countries when the potential returns are so high is what Lucas[x] called 'political risk'. Lucas described 'political risk' as an imperfection or absence in the mechanism for enforcing international borrowing agreements. Put differently, one explanation for the reason FDI does not flow into developing countries where returns are greatest is because this relationship is a possible equilibrium when property rights are not protected.

Domestic competition related policies also play an important role in attracting FDI. In particular, the less costly it is to start a business the greater FDI inflows – especially in developing countries[xi]. Improving domestic competition regulations can even make countries less abundant in natural resources more competitive in attracting FDI[xii]. Even if trade is open between two countries and FDI is technically allowed to flow freely between them, a distorted domestic market creates uncertainty for foreign firms and reduces the likelihood of investing. The exception to this pattern would, of course, be a case where the foreign firm has political connections in the domestic market which allow it to bypass the burdensome regulations[xiii].

All else equal, reducing or removing trade barriers will increase FDI as firms considering investing into a particular country will now observe fewer barriers to investment. The degree to which open trade policies or free trade agreements positively influence FDI is entirely dependent on the 'investment climate' and 'political stability' in the host country[xiv]. Put differently the quality of Domestic Competition and Property Rights Protection in a country each combine with the quality of International Competition policy to determine the amount of FDI entering the country. If any of these factors is poor it will divert FDI to a more open, stable environment[xv].

Domestic Credit Stock

In our model, the effect of capital on productivity includes financial capital and natural resources. Domestic credit stock is a measure of the capital provided to the private sector from domestic financial institutions expressed as a percentage of GDP. The more credit available (the greater the supply), the easier it will be for firms and individuals to access that capital and then use it for productive activities. Because it is measured as a percent of GDP, the ease of access is relative to the size of the economy and, so, it is capturing the availability of credit given the size of the economy. This means that comparisons made across countries are picking up the relative ease of access to capital. Also, domestic credit available falls into the Solow critique category of 'economic factors'.

The amount of credit available domestically will depend on how well property rights are protected in a country. For example, the weaker property rights, the less certainty borrowers and lenders have that the arrangement they agree upon will be the reality once the loan is disbursed. This will make lenders less willing to make funds available because the uncertainty generated by poor property rights protection means there is greater risk in lending. In general, the less certain property rights are the less total investment there will be in an economy and the slower will be economic growth[xvi].

All else being equal, liberalising financial markets – and markets in general – will increase the supply of domestic credit, which leads to economic growth[xvii]. Improving the Domestic Competition score in a country can be thought of as liberalisation (with an emphasis on liberalisation in every sector and the added component of government transparency and accountability). However, the financial crises associated with liberalising financial markets in the 1990s provide an excellent example of why improving Domestic Competition alone will not create a thriving financial sector. Countries which liberalised their financial sectors in the 1990s failed to make necessary reforms in Property Rights Protection, International Competition policies, and in other Domestic Competition areas. Examples of existing issues which became detrimental once financial markets were deregulated include: unsustainable fiscal policy, defence of unsustainable exchange rate pegs, absence of meaningful oversight, and growing concern over deposit guarantees[xviii]. Financial institutions are tied – either directly or indirectly through other institutions – to foreign capital. If access to foreign capital markets is restricted, then domestic credit will see a reduced supply in comparison to open access. It has been shown that when a country's access to foreign capital markets is restricted it reduces the supply of domestic credit[xix]. Therefore, policies which lower the International Competition score of a country will lead to a tightening of domestic credit.

Health Expenditures

The Health expenditures per capita variable is a reasonable proxy for health outcomes[xx]. However, it does not always follow that there is a direct correlation between spending and outcomes, and it may well be that better proxies for outcomes exist. The initial goal was to use a measure of health outcomes here, but an ideal single measure of health outcomes is difficult to define because there are many indications of overall health (life expectancy, infant mortality, malnutrition, etc.) and the data for each is not uniformly available. Health expenditures per person are a labour input in the original Solow context. All else equal, a healthier population will be more productive. Also, Health expenditures per capita falls into the 'economic factors' and 'social base' categories in the Solow critique context.

Property rights have a mixed effect on health expenditure. On the one hand, if property rights are protected the returns to innovation can be captured by the innovator, which increases the incentive for people to enter the field and for the government to spend money in the health sector. On the other hand, healthcare is an industry which can generally be characterised by highly inelastic demand and the necessity of large financial and time investments for innovation. High costs and inelastic demand can lead to high prices for medications, equipment, and training. In the face of such high costs, limited government resources may be diverted away[xxi]. However, increased protection of property rights (particularly patent protection) has a positive impact on the availability of medications across countries[xxii]. So, property rights protection has an ambiguous effect on health expenditures on its own. The negative effect on health expenditures from increased property rights protection is due primarily to increased prices. The sources of relatively high prices include inelastic demand, government price controls, and other disincentives to enter a market (fixed costs of launching, potential competition from generics, etc.)[xxiii]. However, these issues apply to developing countries. As countries develop and property rights are more strongly protected, innovation becomes more common domestically (as highlighted above). Thus, strong property rights increase health expenditures when domestic competition and open trade are promoted because countries with these characteristics are stronger economically. Domestic competition improvements will increase the quality of health services and, therefore, the return to health expenditures. One avenue through which this effect occurs is the potential for competition over patients and health insurance subscribers. If hospitals must compete for patients and insurers must compete for clients, quality will improve relative to the case where these entities are not allowed to compete. This is true even when price is regulated; though, a higher regulated price can also lead to higher quality of services. Furthermore, when prices are determined competitively, pries may not rise compared to the regulated price. It stands to reason that competition over insurers will lead hospitals to charge lower prices – particularly if insurers are competing over clients[xxiv]. Also, health expenditures have become linked to international trade relationships. Health services trade is a growing segment and the potential gains in health outcomes and, therefore, returns to health expenditures from trading health services openly have been documented[xxv]. These potential gains can make an important difference globally, as the demand for health services is predicted to grow as populations become "older, wealthier, and subject to more chronic disease."[xxvi]

Fuel, Ore and Metal Exports

The effect of natural resources on productivity is captured using Fuel exports and Ore and Metal exports. These factors clearly have a direct effect on our measure of productivity because GDP includes exports. When a large percent of manufacturing exports consists of these goods, the relative productivity of workers will be impacted. Fuel exports bias GDP per capita upwards because large export values can be generated with relatively few workers. Oil's share of GDP reaches almost as high as 50% for some countries and oil exports can reach a value equal to over 40% of GDP[xxvii]. Ore and Metal exports bias GDP per capita downwards because fairly low export values for the volume of goods produced are generated with relatively many workers[xxviii]. Also, the types of infrastructure and other businesses which exist in high fuel exporting and high ore and mineral exporting countries are different than those which exist in other countries. So, these variables capture their direct effect on productivity as well as the indirect effect generated by the relative dependence of countries on these goods. Also, Fuel exports and Ore and Metal exports fall into the categories of 'economic factors' and 'physical base'.

Human Capital Stock

Our measure of human capital stock in the economy is the "alternate" human capital stock measure introduced by Lee and Lee[xxix]. This measure is a constant-elasticity-of-substitution, or CES, function of unskilled and skilled human capital stock. The two types of human capital stock are themselves the sums of shares of population in each age category (15-19, 20-24, … 60-64) weighted by relative wage rates, across all educational categories. The different categories of education are as follows:

<u>Unskilled Workers:</u>

1. No formal Education

2. Incomplete Primary Education
3. Complete Primary Education
4. Lower Secondary Education

Skilled Workers:

1. Upper Secondary Education
2. Incomplete Tertiary Education
3. Complete Tertiary Education

The importance of the "alternate" human capital measurement is that it is calculated assuming that skilled and unskilled workers are not perfectly substitutable. The authors themselves cite empirical evidence from Goldin and Katz, 2009, Ciccone and Peri, 2005, and Jones, 2014, which reject the claim of perfect substitution. They go on to draw on empirical evidence from Ciccone and Peri, and Jones, which estimate the elasticity of substitution as lying between 1 and 2. In their construction of the measure, Lee and Lee assume the elasticity of substitution to be 2. The human capital stock measure has a positive impact on Gross Domestic Product, as, all else equal, the more highly educated/skilled the population, the higher will be productivity and GDP per capita. While education is certainly an important component in human capital measurements, the authors acknowledge that their measurement does not take into account other factors such as early childhood nourishment. These factors can be captured by the healthy life expectancy regressors included in our regression setup. Another important factor to note is that the dataset was constructed for 5-year intervals between 1870 and 2010. Consequently, we use the 2010 measure for 2011, 2012 and 2013. While there is a lack of variation over years, this factor should adequately capture the differences in human capital stock across countries.

Model 1 Initial Results

Results

The coefficients in the productivity function are estimated using an Ordinary Least Squares regression with heteroskedasticity robust standard errors. The regression's results are as follows:

Table 1:

log of gdp per capita	Coefficient	Standard Error
log of fdi stock	0.362***	0.0254
health expenditure	0.000258***	0.0000
domestic credit provided by financial sector	0.00197***	0.0006
school persistence	0.0217***	0.0023
fuel exports	0.00695***	0.0120
ores and metals exports	-0.00537***	0.0016

Constant	3.592***	0.1430
N	383	
adj. R-sq	0.903	
*** p<0.01		

Each variable is statistically significant at the 99% confidence level and the regression as a whole explains about 90% of the variance in GDP per capita between countries. This production function captures the determinants of productivity within a country at a given time with a high degree of accuracy. The mean absolute prediction error is about 4%, which means that the above regression is roughly 96% accurate when estimating GDP per capita when given the values for the independent variables.

Next, we evaluate the effect of improving a country's score in Domestic Competition, International Competition, and/or Property Rights Protection on the stock of FDI, the stock of domestic credit, and overall health in an economy. Our model counterintuitively shows that school persistence is largely uncorrelated with our policy indicators. This is likely because school persistence can simply be mandated or prohibited by a government regardless of the quality of Domestic Competition, International Competition, or Property Rights Protection. So, we instead use school persistence as a control in our productivity function to control for differences in human capital stock. In reality, for a particular country it is likely that improving the regulatory environment may provide a new path to improve education where necessary. Because the pattern across all countries is ambiguous, we treat school persistence as a control.

Each factor influencing GDP is itself influenced by policy and these policies determine the scores a country receives for Domestic Competition, International Competition, and Property Rights Protection. Therefore, we estimate the impact of the three policy scores on the productivity factors using the following regressions:

$$\begin{aligned}\log FDI\ stock &= \alpha_{fdi0} + \alpha_{fdi1} * Property\ rights + \alpha_{fdi2} \\ &* Domestic\ competition + \alpha_{fdi3} * International\ Cometition \\ &+ \alpha_{fdi4} * (Property\ rights * domestic\ comp) + \alpha_{fdi5} \\ &* (Property\ rights * interntional\ comp) + \alpha_{fdi6} \\ &* (domestic\ comp * international\ comp) + \alpha_{fdi7} \\ &* (Property\ rights * domestic\ competition \\ &* international\ competition)\end{aligned}$$

$$\text{Healh expenditure per cap} = \alpha_{health0} + \alpha_{health1} * Property\ rights + \alpha_{health2} * Domestic\ competition + \alpha_{health3} * International\ Cometition + \alpha_{health4} * (Property\ rights * domestic\ comp) + \alpha_{health5} * (Property\ rights * interntional\ comp) + \alpha_{health6} * (domestic\ comp * international\ comp) + \alpha_{health7} * (Property\ rights * domestic\ competition * international\ competition)$$

$$\text{Domestic credit stock} = \alpha_{dcs0} + \alpha_{dcs1} * Property\ rights + \alpha_{dcs2} * Domestic\ competition + \alpha_{dcs3} * International\ Cometition + \alpha_{dcs4} * (Property\ rights * domestic\ comp) + \alpha_{dcs5} * (Property\ rights * interntional\ comp) + \alpha_{dcs6} * (domestic\ comp * international\ comp) + \alpha_{dcs7} * (Property\ rights * domestic\ competition * international\ competition)$$

In each function, the only explanatory variables entering are the scores for the three policy areas. These scores enter the equations alone and multiplied with other scores. The multiplications represent the interaction effects from changing each score included in the interaction. The coefficients on the scores by themselves represent the change in the dependent variable when that particular score changes and the other scores equal zero. For the interactions, the coefficient represents the effect on the dependent variable of changing at least one score while the other score or scores remains constant – and greater than zero – or of changing all scores in the interaction. If none of the scores for a country equals zero, then the effect of changing one score on the dependent variable will be the total of the individual effect plus all of the interaction effects containing the score that is changing. Changing the score for any of the policy categories will impact each dependent variable through the total effect of the interactions and the solo effect.

The results of the OLS regressions above are:

Table 2	log FDI stock	Health expenditures	Domestic credit stock
Property Rights	-0.652	-3463.2***	-169.5***
	(0.98)	(1059.50)	(39.85)
International Competition	-3.011***	-15.02	-133.5***
	(0.71)	(611.60)	(22.51)
Domestic Competition	-4.845***	-1498.4**	-129.8***
	(0.74)	(631.30)	(20.82)

Property Rights * Domestic Competition	0.475**	792.0***	39.13***
	(0.24)	(280.00)	(9.08)
Property Rights * International Competition	0.374*	496.5**	52.55***
	(0.21)	(245.70)	(9.64)
Domestic * International	1.020***	-115.1	28.68***
	(0.16)	(147.80)	(4.91)
Property Rights * domestic * International	-0.111**	-59.81	-9.895***
	(0.05)	(58.74)	(1.89)
Constant	19.17***	6186.5***	535.6***
	(2.63)	(2194.00)	(78.99)
N	807	803	774
adj. R-sq	0.634	0.623	0.493
Standard errors in parentheses	* p<0.10	** p<0.05	*** p<0.01

It is important to remember that the effects of changing a score in one policy are equal to the total effect from each component of the regression. So, a negative coefficient should not be seen as a negative impact on the dependent variable from improving a score, but should be seen as reducing the positive impact of the effect from the change somewhere else in the regression. This portion of the model explains between 49.4% and 63.4% of the variation in the factors affecting productivity.

This level of accuracy appears to be much greater than other comparable indicators, such as the World Economic Forum's Global Competitiveness Indicators which have an accuracy of about 19% when used to predict GDP per capita. That is, when using the WEF's own indicators in the regression structure they suggest, the regression has a mean absolute prediction error of about 19%. This is likely due to the fact that the WEF's GCI indicator is a single value which is meant to capture the overall competitiveness of a country and, therefore, the indicator generates a weighted average of very different types of variables (such as cost of terrorism and telephony, as one example). Also, the WEF indicator includes many variables which are actually the direct result of the competitive environment, as opposed to characteristics of a pro-competitive environment. Finally, the WEF suggests a very simple linear regression which directly estimates the change in GDP per capita through the GCI score and GDP growth. This fails to capture the fact that changing policy does not increase GDP directly (that is, removing a distortion is only productivity enhancing because it allows participants in the market to optimize their behavior, not because the policy itself is productive). Our model is much more streamlined and parsimonious than other models, and is different from other models because of the importance it ascribes to competition, which is partly why it is more accurate.

To determine the impact of improving a score in one or more policy areas on GDP per capita we find the impact of changing that score on each of the three policy areas above and then calculate the impact of that change in each of the three areas above on GDP per capita. For example, if property rights protection increases by 1, domestic competition equals 4, and international competition equals 3, then log of FDI stock will increase by 1.038, Health expenditures will increase by 476.58, and domestic credit stock will increase by 25.93. These increases will then increase log of GDP per capita by 0.55, which is equivalent to a 70% increase in productivity.

We discounted an approach that would estimate the equations for FDI stock, domestic credit stock, and health expenditures, using the fitted values from these estimates as the values in the regression on the log of GDP per capita, because the goal for this process is to find the impact of changing the policy area scores on GDP per capita. Since this is not a direct effect, we need a production function which would accurately estimate log of GDP per capita using independent variables which are influenced by the policy area scores. We then estimate functions for FDI stock, domestic credit stock, and health expenditures that are functions of the policy area scores and where the policy areas were statistically significantly influential and where the function as a whole was statistically significant. The functions did not need pin-point accuracy, but the coefficients on each policy area and the interactions needed to be accurate.

Estimating Weights

To calculate the scores for each policy are we took the data points for the WEF GCI and the World Bank's Doing Business Index and rearranged them into subcategories in each policy area (See the appendix for the exact subcategories and data points). We then estimated the models for each productivity factor (which are functions of the scores, as shown above) repeatedly, adjusting the weights of each variable and subcategory each time. The fitted values for the productivity factors as a function of these scores were then used as the data points for the productivity model. The predictive power (estimated as the mean absolute prediction error) of the productivity model was recorded and the process was repeated using new weights for the data points and subcategories. We assigned a random weight to each potential indicator in each subcategory and a weight for each subcategory in each policy area. Then, the equations for FDI stock, domestic credit stock, health expenditures, and school persistence were estimated using OLS regressions. The fitted (or predicted) values for each regression were then used to estimate the regression for GDP per capita. The mean absolute prediction error was calculated as a percent of GDP per capita. Then, the program assigned a new weight to each value and subcategory, re-ran the regressions, and then predicted GDP per capita using the new fitted values. We repeated this process in order to minimize the distance between the mean absolute prediction error and perfect predictive power (0 prediction error). The resulting weights predicted GDP increases with 93%

accuracy, using the simple regression set up, and now predict GDP increases with 96% accuracy using the current framework. See the Appendix for the structure of the index and the weights for each subcategory and variables within the subcategories.

The goal was to minimize the mean absolute prediction error of the productivity model, while maintaining statistically significant explanatory power of the scores themselves in the models of productive factors as functions of the scores. The program would throw out any scores which did not yield any statistically significant coefficients in the models for productive factors. We also restricted the weights to be integer percentage values (ie, 1%, 2%, 3%, etc., but not 1.5% or 2.5%, for example) and did not allow any of the data points or subcategories to hold no weight. In the end, the scores which generated fitted values for the productive factors which then yielded the smallest mean absolute prediction errors for the model of productivity were chosen and the weights associated with these scores used.

Empirical Implementation – Model 1 Variant α

<u>Pooled OLS and Time Invariance</u>

We now set out a variation on the model set out above. Despite the potential for different exact specifications, we restrict our analysis to the linear class of estimators. Due to the interaction effects included in the base regressions, we have a variant of the trans log regression model, which represents a second-order approximation to the actual function used. Therefore, the linearity of our model should not restrict its ability to capture potential non-linearities. Moreover this variation on the model attempts to deal with some of the endogeneity problems of the initial model.

In applying a pooled regression with all time and country observations as different, unstructured observations, we follow a broad variety of literature on empirical political economics. While the FE model is usually employed to differentiate out entity-fixed effects, this ignores clustering and covariance across countries (Plumper & Troeger, 2007). Additionally, FE is not applicable in our specific case, as we have only three time periods with a high number of observations (high N, low T), which compromises the stability and hence the out-of-sample validity of the FE estimator. Additionally, as presented by the literature on time-invariant estimators, our indices for property rights, domestic competition and international competition are all relatively invariant over time (we also apply the same human capital estimates for each country for all three years as data is issued in 5-year periods). Any changes cannot be drastic, since it is a weighted average across a multitude of aspects. Since the FE estimator performs very poorly in the presence of time-invariant variables, Plumper & Troeger suggest a three-step approach based of Pooled OLS, where the regressor matrix is decomposed. In general, this suggests that Pooled OLS should perform better than regular FE in our case in particular. Alternative FE approaches such as the Time-Fixed Effects model, with differences both across countries as well as time periods does not allow for succinct predictions across time periods. Pooled OLS allows us to cover the variations over entities more flexibly, which is favourable due to the high number of entity observations.

One major drawback of OLS in this setting is the strong potential for endogeneity, which can arise as a result of omitted variable bias (it is difficult to cover all explanatory variables) as well as the reverse causality imposed through the operation of the government. Higher GDP on average implies higher tax revenue, which also increases the provision of human capital, health care and potentially leads to higher FDI due to better security and property right enforcement. The additional inclusion of ore and metal as well as oil exports in our model allows us to differentiate cases such as Nigeria where GDP is higher than it would otherwise be due to rent extraction of these resources, but education and property right enforcement are not necessarily improved through this surplus income, and the base requirements for optimised economic growth across the three pillars is not met. Therefore, we will likely have an upward bias on our estimate, which we would need to correct using an instrumental variables (IV) approach. In academic literature, significant criticism of Instrumental Variable approaches has been put forward, e.g. by Young (2018). Young suggests that IV estimates cause significant bias in cases of non-i.i.d. observations as is the case due to our use of time-series as well as covariance across countries. Therefore, a regular 2SLS approach would lead to significant bias, suggesting the use of regular OLS instead. For this situation, dynamic panel data models have been suggested in previous literature, however due to the lack in time periods, its application would be non-sensical leaving us to estimate the rather simplistic model for reasonable rough estimates.

Issues of autocorrelation and unit roots in the time series could have been resolved through the FE approach, as the Kwiatkowski-Phillips-Schmidt-Shin-Test (KPSS-Test) is significant in case of the non-differenced data but no longer so after differencing. Note that this is however a minor issue since we observe only 3 time periods.

Another issue lies in the time-period our estimates are related to since we aim to make predictions. While the OLS estimate does not have any relation to time periods (the FE estimator is the difference exercised within one year), we cannot estimate annual increases in GDP, since it is not possible for index changes to fully take effect after one year. Nevertheless, OLS allows us to summarily estimate the effect of the total reduction in ACMDs for the entire time period of effect and then infer annual growth rates. We would then assume that the time period of effect is 15 years. Note that this acts as a lower-bound to our estimates, since the growth rates would normally compound. Therefore, for a reasonable range of difference in index scores, our estimation based on the trans log function is accurate to estimate the total effect, which we can use to derive the Effective Annual Rate as a geometric fraction of total growth.

Functional Form

The functional form of a regression is important, as incorrect functional forms can lead to bias in the estimates of our parameters. Consequently, in order to test the functional form of our model above, we use the Ramsey RESET test[xxx], where the null hypothesis is: Nonlinear Combinations of the regressors have no significant explanatory power. Specifically, in the Ramsey test, when we have the regression function:

$E(y|X) = X\beta$

The RESET test then tests if the coefficients for all powers of the regressors (Xβ)k are significant, i.e. in the regression y = Xβ + X2θ1 + X3θ2 + ... whether we can reject

H0: θ1 = θ2 = ... = 0

Upon applying the RESET test, we obtain the following result:

```
Ramsey RESET test using powers of the fitted values of loggdppc
       Ho:  model has no omitted variables
                F(3, 223) =     48.64
                 Prob > F =      0.0000
```

Given the low p-value of the test, we need to modify the functional form of the regression by including potential powers of the variables. In this linear setup, the inclusion of squared terms did not improve the fit, since these transformed variables were highly insignificant. This is shown in the following regression table:

(a) OLS Log GDP per Capita on Factors

	loggdppc
Intercept	2.0594***
	(0.1518)
logfdipc	0.3489***
	(0.0239)
Domcredpc	0.0000*
	(0.0000)
healthexppercapita	0.0002***

	(0.0015)
sch-enr	0.0221***
	(0.0015)
fuelexports	0.0029**
	(0.0013)
oreandmetal	-0.0088***
	(0.0025)

(b) OLS Factors on ACMD index scores

	domcredpc	healthexppercapita	logfdipc
Intercept	1991694.4465**	139452.9246***	42.4651
	(917662.9997)	(44970.8353)	(47.6320)
propertyrights	-737475.5187***	-47774.5284***	-13.7575
	(271929.3622)	(13326.1236)	(14.1147)
domesticcomp	-322195.5890*	-23420.9841***	-5.4755
	(170184.3796)	(8340.0265)	(8.8336)
internationalcomp	-279394.6490	-22147.9209**	-9.8353
	(176599.5722)	(8654.4083)	(9.1665)
pdc	119871.2912**	7841.1239***	2.8836
	(49284.8482)	(2415.2448)	(2.5582)
pic	104415.8806**	7019.9042***	2.2272
	(49772.1939)	(2439.1276)	(2.5835)
dcic	44490.6349	3870.5191**	1.4454
	(32893.3235)	(1611.9646)	(1.7074)
pdcic	-17754.1528**	-1287.1631***	-0.4803
	(8902.1756)	(436.2585)	(0.4621)
p sq	9270.9824*	821.0168***	0.1355
	(5124.9463)	(251.1522)	(0.2660)
d sq	-1508.9270	-100.1327	-0.3353
	(4739.9420)	(232.2848)	(0.2460)
i sq	1564.5700	161.4959	0.4910*

	(4981.2794)	(244.1117)	(0.2586)

We attempted to run the regression using logarithms of all variables, with the following result:

Upon using the Ramsey RESET test for the above regression, we obtain the following result:

```
Ramsey RESET test using powers of the fitted values of loggdppc
       Ho:  model has no omitted variables
                  F(3, 208) =      2.38
                   Prob > F =      0.0712
```

Consequently, we cannot reject the null at a 5% level of significance, i.e. there does not seem to be a case of omitted variable bias[xxxi]. Note however that the full-log model has a number of problems. First, since the Ramsey test is not rejected, we can only say that $\log(X)^2$ has no explanatory power, it's therefore not a natural extension of the initial linear model. Additionally, the full logs model is not actually a valid GM model, since we cannot assume that E(log()) = 0, since simply assuming E() = 1 does not resolve this (Jensen's Inequality). We therefore implement the Translog-regression model as our functional form, since this is a second-order Taylor approximation which can deal better with the potential non-linearities the test suggests. The table below represents the results of the translog model, having a very high $R^2 \approx 0.98$.

The Ramsey RESET test then implies that this specification is very unlikely to have omitted variables:

Next, we evaluate the effect of improving a country's score in Domestic Competition, International Competition, and/or Property Rights Protection on the stock of FDI, the stock of domestic credit, and overall health in an economy. Note that we explicitly choose to use health expenditure as our proxy for health outcomes and its influence on the productivity of an economy. Acemoglu & Johnson (2007) noted the potential reverse causality which can arise as outlined in the previous section as a cause of endogeneity. Acemoglu & Johnson resolve this problem by using life expectancy to avoid the direct link of expenditure to GDP.

However, for our analysis, these measures (including the "healthy life expectancy" by the WHO) are not suitable since they are strongly correlated with the security and crime outcomes within the country, which imposes bias on our estimates as these variables are not included in our regressions[xxxii]. Health expenditure therefore notes the effort the government takes in order to improve health outcomes rather than the actual health outcomes, which is of greater interest to assess the regulatory environment.

Each factor influencing GDP is itself influenced by policy and these policies determine the scores a country receives for Domestic Competition, International Competition, and Property Rights Protection. Therefore, we estimate the impact of the three policy scores on the productivity factors using the following regressions:

$$\log(\text{FDI stock}) = \alpha 0 + \alpha 1 *\text{Propertyrights} + \alpha 2 *\text{Domestic Competition} + \alpha 3 *\text{International Competition} + \alpha 4 *(P*D) + \alpha 5 *(P*I) + \alpha 6 *(D*I) + \alpha 7 *(P*D*I) + e \quad (2)$$

$$\log(\text{Health Exp.}) = \beta 0 + \beta 1 *\text{Propertyrights} + \beta 2 *\text{Domestic Competition} + \beta 3 *\text{International Competition} + \beta 4 *(P*D) + \beta 5 *(P*I) + \beta 6 *(D*I) + \beta 7 *(P*D*I) + e \quad (3)$$

$$\log(\text{Dom. Credit}) = \gamma 0 + \gamma 1 *\text{Propertyrights} + \gamma 2 *\text{Domestic Competition} + \gamma 3 *\text{International Competition} + \gamma 4 *(P*D) + \gamma 5 *(P*I) + \gamma 6 *(D*I) + \gamma 7 *(P*D*I) + e \quad (4)$$

Note that for these growth regressions we maintain a simple linear function. As evident from table (b) above, including squared terms does not improve results since these terms are all non-significant. When we make specific functional forms, we are actually imposing restrictions, which reduces the degrees of freedom and hence the precision of our (confidence interval) estimates. The following tables document the regression results:

Linear regression

Number of obs	=	238
F(7, 230)	=	85.31
Prob > F	=	0.0000
R-squared	=	0.7174
Root MSE	=	1.2005

logdomcredpc	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
propertyrights	-45.36414	5.865222	-7.73	0.000	-56.92057	-33.80771
domesticcompetition	-21.64155	3.132942	-6.91	0.000	-27.81448	-15.46861
internationalcompetition	-23.4501	2.56925	-9.13	0.000	-28.51237	-18.38783
pdc	7.857626	.9617048	8.17	0.000	5.962748	9.752503
pic	8.714753	1.04108	8.37	0.000	6.66348	10.76603
dcic	3.993458	.5741513	6.96	0.000	2.862189	5.124727
pdcic	-1.452962	.1645207	-8.83	0.000	-1.777122	-1.128802
_cons	128.6547	14.06244	9.15	0.000	100.947	156.3623

Linear regression	Number of obs	=	218
	F(6, 211)	=	1867.27
	Prob > F	=	0.0000
	R-squared	=	0.9808
	Root MSE	=	.20719

loggdppc	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
logfdipc	.0219939	.0152813	1.44	0.152	-.0081296	.0521174
logdomcredpc	.1993074	.0266741	7.47	0.000	.1467256	.2518892
loghealthexppc	.5508669	.0352349	15.63	0.000	.4814094	.6203244
loghcalt	.1830307	.0988446	1.85	0.065	-.0118187	.37788
logfuelexports	.0171961	.0056907	3.02	0.003	.0059781	.0284141
logoreandmetal	-.0318582	.0111713	-2.85	0.005	-.05388	-.0098365
_cons	3.374452	.1182889	28.53	0.000	3.141272	3.607631

lnhexpdom	-.1788993	.0434437	-4.12	0.000	-.26486	-.0929386
~~_cons~~	~~3.103433~~	~~.5299044~~	~~5.86~~	~~0.000~~	~~2.054927~~	~~4.151939~~
loghealthexppc	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]

Linear regression	Number of obs	=	251
	F(7, 243)	=	51.06
	Prob > F	=	0.0000
	R-squared	=	0.6095
	Root MSE	=	1.2959

logfdipc	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
propertyrights	-26.56673	6.806046	-3.90	0.000	-39.97311	-13.16036
domesticcompetition	-13.82163	2.778067	-4.98	0.000	-19.29379	-8.349462
internationalcompetition	-15.06177	2.794152	-5.39	0.000	-20.56561	-9.557917
pdc	4.476134	1.123016	3.99	0.000	2.264046	6.688223
pic	5.311904	1.244433	4.27	0.000	2.860652	7.763156
dcic	2.61318	.5248795	4.98	0.000	1.579286	3.647074
pdcic	-.8581171	.1990616	-4.31	0.000	-1.250224	-.4660107
_cons	82.54193	14.36114	5.75	0.000	54.25373	110.8301

Ramsey RESET test using powers of the fitted values of loggdppc

Ho: model has no omitted variables

F(3, 125) = 0.74

Prob > F = 0.5289

Consequently, we use the coefficients from the regressions we have, to project the impact of the reduction in distortions across the three pillars, for the United Kingdom in particular.

Growth Projections over Time

We combine the coefficients from the Translog-regression and the index regressions and can use this as a function to arrive at GDP estimates for any combination of the index scores.

The model produces an indication of what the potential economic growth that could be unleashed on a productivity basis. It does not say anything about how long it would take governments to reduce the ACMDs in their domestic regulatory environment, negotiate trade liberalisation or put in place the necessary legislation, and dispute settlement mechanisms to support property rights protection. We have made some assumptions but the yearly rate of growth is obviously dependent on how fast governments can move.

We have assumed a specific time frame over which a reduction in ACMDs takes place (in this case 30 years for example). Starting from the UK indices in 2013 over 30 years, we have three scenarios, corresponding to an annual reduction of ACMDs (and consequent rises in index scores) of 2, 5 and 10%, respectively. We then calculate the annual growth rate from this total growth over 30 years and apply it sequentially to arrive at the above figures. For comparison, we included the PWC 2030 estimates of annual growth rates (1.1 %, although this depends on the scenario in consideration). On average, we arrive at a level of £200,000 per capita after 30 years, which corresponds to an annual growth rate of approx. 6%. Note that this growth rate estimate is of course entirely dependent on the assumed time frame of the change. For a 15-year period, this figure rises to 11% per cent.

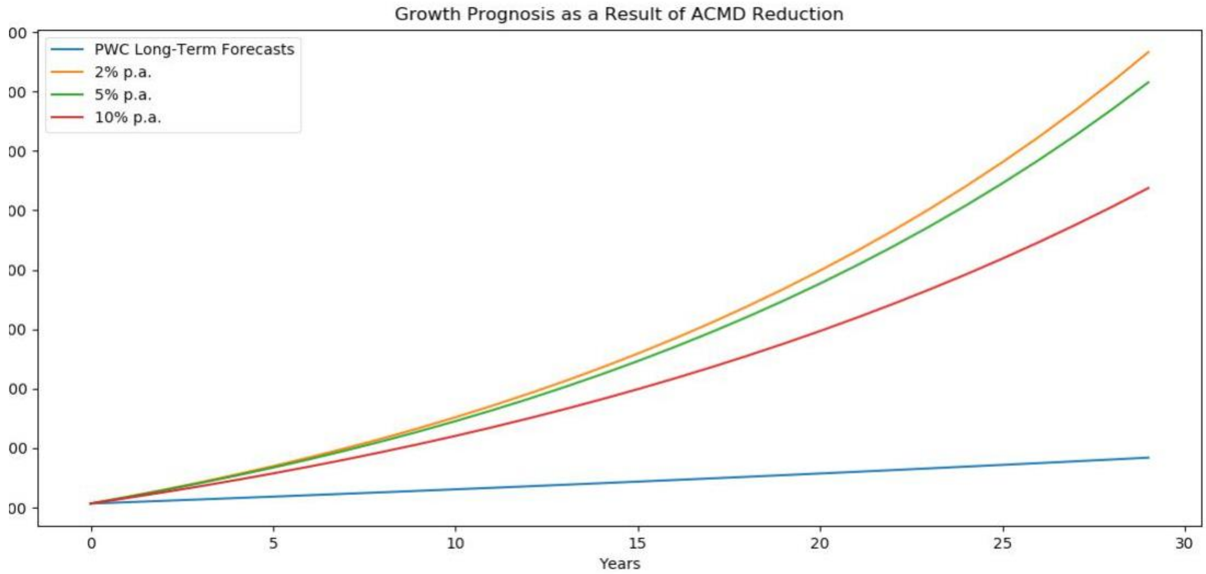
Consequently, we use the coefficients from the regressions we have, to project the impact of the reduction in distortions across the three pillars, for the United Kingdom in particular.

Discussion and Conclusion

The growth projections suggest that slight reductions in ACMD distortions, e.g. at the 2% level, would lead to higher welfare gains for the UK than very radical reductions of 10% for instance. This is a counter-intuitive result, and could be explained by the choice of variables especially in the competition pillar. If the variable choices are too focused on allocative efficiency and not productive efficiency as well, or priories the pursuit of perfect competition, we may get the perverse result we see because cannibalistic competition is wealth destructive. Further work will be done in future iterations of the model to correct for these errors. However, this does suggest that policymakers must be careful in how they interpret the need for competition, and should ensure that genuinely pro-competitive outcomes (as measured by consumer welfare enhancement) are actually secured.

Our model suggests that no change in ACMD levels is approximately equivalent to an annual reduction of 5% in distortions per year. Hence any moderate reductions in ACMDs up to index scores of ~ 6.45 would lead to relative gains in GDP compared to the no-reduction case, whereas strong reductions beyond this appear to have a negative influence. It is not surprising to see this parabolic development in response to reductions, since we are dealing with historical data[xxxiii]. It may also be that ACMDs provide rich countries with a temporary unfair competitive advantage over others on the international market and therefore make it seem like less competition leads to higher welfare in total by exploiting monopoly/oligopoly surplus. In innovation economics, it is still debated whether excessive competition can become damaging to innovation, e.g. when patents are not enforced and therefore reduce the incentive shares for introducing better technologies. Most of the 3D diagrams also demonstrated this decrease when approaching a "full-7" scenario from an already high level of index scores.

While we cannot demonstrate the benefits of perfect competition since we have no observational data on this, our analysis allows us to conclude that reductions in ACMDs will unambiguously improve welfare in all countries within a certain range, but further work will have to be done to explain the results outside of this range where multiple effects may be occurring.



Learnings from Initial Model and α Variation

Many of the variables we have used in the initial model and the α variation reward a country for approaching conditions of perfect competition. As we have hinted, the problem with this approach and one reason it may be yielding the odd result that a significant reduction of distortions can lead to negative economic outcome for the country is the difference between a consumer welfare enhancing market outcome and a perfectly competitive one. This is consistent with the analysis in the previous chapter suggesting that better economic outcomes can be achieved when productive and allocative efficiency are maximised, than when competition is "perfect". This is also consistent with economic theory such as Demsetz's 1968 paper which indicates that there is no economic theory that suggests that a fragmented market is in and of itself a public good, and that this view stems from a misunderstanding of the purposes of competition and rivalry.[xxxiv] Many of the variables used proxy reward countries for more perfect competition. Further variables will need to be developed in order to see whether the choice of variables explains this behaviour or if there is another cause. The authors anticipate a β version of the model to be developed shortly which will take this more fully into account.

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[i] There have been a number of attempts to model the economic impact of ACMDs. There is ongoing work emanating out of the Singham-Rangan-Bradley model, and there is also work done by the Centre for Economics and Business Research, *see* Shanker A. Singham and Douglas McWilliams, "Improving the Economic Modeling of Trade Agreements," Cebr (20 May 2020), https://cebr.com/reports/improving-the-economic-modelling-of-trade-agreements/.

[ii] "Foreign Direct Investment: Inward and Outward Flows and Stock, Annual – 1970-2020," UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT (UNCTAD) STAT (n.d.), http://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=96740.

[iii] *See* Jong-Wha Lee and Hanol Lee, *Human Capital in the Long Run*, 122 J. OF DEV. ECON. 147 (2016).

[iv] For data on health expenditures per cap, domestic credit stock, fuel exports, and ore and metal exports, *see* "DataBank," THE WORLD BANK (n.d.), http://databank.worldbank.org/data/home.aspx.

[v] 24Source for health expenditures per cap, domestic credit stock, fuel exports, and ore and metal exports: http://databank. worldbank.org/data/home.aspx

[vi] John Williamson, *What Washington Means by Policy Reform*, *IN* LATIN AMERICAN ADJUSTMENT: HOW MUCH HAS HAPPENED? (John Williamson ed., 1990).

[vii] Samuel Adams, *Intellectual Property Rights, Investment Climate, and FDI in Developing Countries*, 3 INT'L BUS. RES., no. 3 (2010).

[viii] *Id.,* Adams shows that patent protection had a greater, positive influence on FDI after the adoption of TRIPS, which tells us that committing to protecting intellectual property and actually increasing patent protection together attracted more FDI..

[ix] Ravi Ramamurti and John P. Doh*, Rethinking Foreign Infrastructure Investment in Developing Countries*, 39 J. OF WORLD BUS. (2004).

[x] Lucas, Jr., Robert E. Why Doesn't Capital Flow from Rich to Poor Countries? The American Economic Review 80 (2):92-6. May 1990.

[xi] Nihal Bayraktar*, Foreign Direct Investment and Investment Climate*, 5 PROCEDIA ECON. AND FIN. 83, no. 5 (2013).

[xii] Emmanuel Nnadozie, and Angelica E. Njuguna*, Investment Climate and Foreign Direct Investment in Africa* (2013), *as prepared for* "The 6th African Economic Conference," Conference, Addis Ababa, Ethiopia (26-28 Oct 2011).

[xiii] Pan, Yigang, et al. Firms' FDI ownership the influence of government ownership and legislative connections. Journal of International Business Studies. Vol 45. 2014.

[xiv] This interdependence has been documented many times. Some examples include John H. Dunning, *The Role of Foreign Direct Investment in Upgrading China's Competitiveness*, 4 J. OF INT'L BUS. AND ECON. (2003).; *World Investment Report,* UNCTAD (1998, 2012) (numerous reports, but the 1998 and 2012 report focus on trends in determinants of FDI and investment climate, political stability, and openness of trade are factors in each report).

[xv] This interdependence has been documented many times. Some examples include John H. Dunning, *The Role of Foreign Direct Investment in Upgrading China's Competitiveness*, 4 J. OF INT'L BUS. AND ECON. (2003).; *World Investment Report,* UNCTAD (1998, 2012) (numerous reports, but the 1998 and 2012 report focus on trends in determinants of FDI and investment climate, political stability, and openness of trade are factors in each report).

xvi Numerous studies show this relationship. A few examples include Robert J Barro*, Economic Growth in a Cross Section of Countries*, 106 Q. J. OF ECON. 407 (1991).; Paolo Mauro, *Corruption and Growth*. 110 Q. J. OF ECON. 681 (1995).;

Besley, Timothy. Property Rights and Investment Incentives: Theory and Evidence from Ghana. The Journal of Political Economy. Vol. 103, Issue 5. Oct 1995. Pp. 903-937.

xvii *See*, for example, Ross Levine, Norman Loayza, and Thorsten Beck, *Financial Intermediation and Growth: Causality and Causes,* 46 J. OF MONETARY ECON. (2000).; Ross Levine and Sara Zervos, *Stock Markets, Banks, and Economic Growth*, The 88 AM. ECON. REV. 537 (1998).

xviii *Financial Liberalization: What Went Right, What Went Wrong?*, *in* ECONOMIC GROWTH IN THE 1990S: LEARNING FROM A DECADE OF REFORM (Roberto Zagha and Gobind T. Nankani, eds., 2005).

xix Shekhar Aiyar and Sonali Jain-Chandra, *The Domestic Credit Supply Response to International Bank Deleveraging: Is Asia Different?,* IMF Working Paper no. 12/258. INTERNATIONAL MONETARY FUND (2012).

xx The literature supports the use of health expenditures as a proxy for health outcomes, *see*

Marwa Farag et al., *Health Expenditures, Health Outcomes and the Role of Good Governance*, 13 INT'L. J. HEALTH CARE FIN. ECON. 33 (2012) (Shows that health expenditures reduce child and infant mortality rates in low- and middle-income countries and that good governance improve this effect); Farasat A. S Bokhari, Yunwei Gai, and Pablo Gottret, *Government Health Expenditures and Health Outcomes*, 16 Health Econ. 257 (2007) (Shows that health expenditures reduce infant and maternal mortality rates across all income levels); John C. Anyanwu, and Andrew E. O. Erhijakpor, *Health Expenditures and Health Outcomes in Africa*. Working Paper No. 91, AFRICAN DEVELOPMENT BANK (2007) (Shows that the relationship between health expenditures and child and infant mortality rates holds for Africa);

Isabelle Joumard, Christophe André and Chantal Nicq, *Health Care Systems: Efficiency and Institutions*, OECD Economics Department Working Papers, No. 769, ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (2010) (Shows that 40% of the increase in life-expectancy since 1990 for OECD countries can be attributed to increases in health expenditures).

xxi Iain M. Cockburn, *Intellectual Property Rights and Pharmaceuticals: Challenges and Opportunities for Economic Research*, *in* THE ECONOMICS OF INTELLECTUAL PROPERTY (2009).

xxii Ernst R. Berndt, Nathan Blalock, and Iain M. Cockburn, *Diffusion of New Drugs In The Post-TRIPS Era*," 18 Int'l J. of The Econ. of Bus. 203 (2011).

xxiii *Id*

xxiv Martin Gaynor and Robert J. Town*, Competition in Health Care Markets*, NBER Working Paper 17208, NAT'L BUREAU OF ECON. RES. (2011).

xxv Patricia Waeger, *Trade in Health Services: An Analytical Framework*, Kiel Advanced Studies Working Papers no. 441, KIEL INST. FOR THE WORLD ECON. (2007).

xxvi *Recent Trends in US Services Trade – Annual Report 2013*, USITC Pub. 4412, US International Trade Commission (2013).

xxvii Nasri Harb, *Oil Exports, Non-Oil GDP, and Investment in the GCC Countries*, 13 Rev. of Dev. Econ. 695 (2009).

xxviii Graham A. Davis*, Trade in Mineral Resources: Background Paper to the 2010 World Trade Report*, Staff Working Paper ESRD-2010-01, Economic Statistics and Research Division, WORLD TRADE ORGANISATION (2010).

xxix *Human Capital in the Long Run, supra* note 28, at 147-169.

xxx J. B. Ramsey, *Tests for Specification Errors in Classical Linear Least Squares Regression Analysis*, 31 J. OF THE ROYAL STAT. SOC. 350 (1969).

xxxi Nevertheless, it is possible to reject at the 10% level, so the omitted variable issue is not entirely resolved.

xxxii The direction of the bias on the estimated effect of health expenditure is also strongly GDP-related. Accordingly, high-GDP countries will have overstated effects of health expenditure, whereas low-GDP nations have an underestimated health expenditure effect. For instance, Ukraine had a much higher number of hospital bed provision than many Western nations.

xxxiii Since we are dealing with historical data and there are no observations with a (7,7,7) index score profile, this shows that we have limited out-of-sample validity for our estimation.

xxxiv Harold Demsetz, *Why Regulate Utilities?*, 11 J.OF L. AND ECON. 55 (1968).