Institutions, Economic Growth, Wellbeing and Causality Dominance

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Introduction.

One of the quintessential issues in development economics is the interaction between institutions (polity) and economic outcomes and their contribution to overall wellbeing. Changes in polity and economic wellbeing are readily observed, whether or not they have jointly contributed to improvements in overall wellbeing is much more difficult to ascertain unless changes are in the same direction for both concepts (which they have not been). In terms of their interaction while a positive correlation between these two variables has been readily established, causality has proven more contentious. Theoretically, causality can run in both directions. To the extent that better institutions such as property rights, political freedoms and government accountability provide better investment incentives, they can be expected to encourage economic activity. At the same time though, prolonged economic failure may compel agents to demand better institutions and any growth that makes these agents richer or more educated might also give them the extra bargaining power needed to make these demands credibly.

On the empirical front, with somewhat broad brushes Sen (1999) documents many of the intricacies of the growth and freedom relationship sometimes alluding to causalities in both directions whereas Friedman (2005) seems to argue that the causal direction is from growth to freedoms rather than the reverse. Both authors convey the notion that both economic growth and the development of political freedoms are key ingredients for societal and individual wellbeing. A key study that finds causality from institutions to economic performance is Acemoglu et al (2001). They argue that the institutions introduced by European colonizers varied according to their settlement objectives and show that the persistence of these institutions to the present day has had important income per capita implications for the ex-colonies. Using a growth accounting framework, Hall and Jones (1999) also argue for the primacy of institutions, finding that differences in social infrastructure help explain the large differences in capital accumulation and productivity that we observe across countries. More recent work by Gwartney et al (2006) confirms the importance of such an institutions-investment channel while Dawson (2003) identifies freedoms related to international finance as those which affect growth through investment and freedoms related to political, civil, and economic liberties as those which affect growth directly. Consistent with Calderon and Chong (2000) and Kaufmann and Kraay (2002), however, both Dawson (2003) and Gwartney et al (2006) also find evidence of reverse causality when certain institutional measures are used. The importance of disaggregating institutions is further established by the Heckelman (2000) result that an average measure of freedom along with its monetary, capital, and property rights components precedes growth but that growth likely precedes the extent of government intervention. A consistent conclusion is reached by Alvarez and Vega (2003) who find clear evidence of causality from institutions to growth when institutions are measured as economic freedoms but confounded evidence when they are measured as political freedoms.

Similar debates have also emerged in the financial development literature. Beck et al (2000), for example, argue that legal and accounting institutions are particularly important for an economy's growth because they determine the sophistication of its financial intermediaries. The results of King and Levine (1993) also suggest that the pre-determined component of financial development is a good predictor of long-term growth while Rajan and Zingales (1998) find that sectors in need of external finance develop more quickly in economies with better financial markets. Morris et al (2001), on the other hand, find evidence of reverse causality in some OECD countries and two-way causality in others but no decisive evidence that the link between financial development and economic performance runs strictly from the former to the latter. Using a Geweke decomposition to test for linear feedback between financial deepening and growth rather than the unidirectional Granger procedure typically employed, Calderon and Liu (2003) also find that causality runs in both directions with financial systems exerting a larger effect on growth in developing countries.

That the debate is far from settled is also reflected in several papers which have raised questions about the econometric methods used to investigate the relationship between growth and institutions. Levine and Renelt (1992), for example, demonstrate that slight changes in the list of explanatory variables can overturn the results of many empirical growth studies while De Haan et al (2006) also criticize the specification of certain growth models used in the literature. Perhaps the most searing criticism though is provided by Glaeser et al (2004) who argue that traditional methods for testing the relationship between institutions and economic outcomes are flawed and, once proper measures and valid instruments are employed, institutions only have a second-order effect on economic performance. The task of interpreting the literature is further complicated by the Doucouliagos (2005) finding of a publication bias towards the conclusion that economic freedoms have a positive impact on growth, suggesting that the lack of consensus may be more pronounced than it appears.

The fact is “freedom causes growth” and “growth causes freedom” are not mutually exclusive hypotheses, reality is probably a mixture of both. In both cases the linkages are unlikely instantaneous, it is in the nature of things that it will take time for increases in economic power (growth) to bring about improvements in institutions just as it will take time for improvements in institutions to bring about improvements in wellbeing. Indeed the possibility of feedbacks is very real with growth promoted institutional improvements in turn promoting economic growth and so on. The point is that it is likely that causality will be perceived empirically in both directions the question really one of ascertaining the “dominant” hypothesis.

In light of the preceding discussion, the present paper goes beyond conventional regression methods and analyzes the extent to which economic growth and the development of political freedoms can be jointly responsible for improving wellbeing and examines the relationship between institutions and economic outcomes in the context of a notion of causality dominance. The data employed are the Polity Indices (Jaggers and Marshall (2007)) and GNP per capita in constant 2000 US$ (drawn from the World Bank Development Indicators source) for 84 countries over 5 year intervals from 1960 to 2005. A problem with this data combination is that the Polity Index is a discrete variable whereas the GNP data are continuous rendering conventional regression techniques for establishing causality problematic. We draw from the multivariate stochastic dominance literature to examine whether successive observations on Polity and GNP per capita correspond to a wellbeing improvement in a specific sense by adapting multivariate stochastic dominance techniques for use with a mixture of discrete and continuous variables. The causality issue is examined via the use the overlap index proposed by Anderson et. al. (2009), (2009a), again adapted for use with a mixture of discrete and continuous variables, to measure a more general concept of inter-temporal dependence rather than just the inter-temporal correlation underlying regression techniques which is confined to a stricter notion of linear dependence.

With regard to dependence dominance the basic premise is that the extent to which the joint density of two variables overlaps the product of their marginal densities (call it OV) over all points of support in the joint distribution is a measure of the extent of their independence. If the match was perfect, i.e. the joint density equaled the product of the marginal densities at every point of support, then the variables would be independent and OV would equal 1. If there were a lesser match the overlap would be less than one. In effect OV is an index of the degree of independence defined on the unit interval and somewhat obviously D = 1 - OV becomes a measure of the extent of dependence between the two variables. If institutions do indeed determine economic outcomes more than the reverse the D corresponding to earlier institutions and later wellbeing outcomes should be systematically greater than that of earlier wellbeing outcomes and later institutions and vice versa. Using this approach, we can admit non-linear[1] relationships and bypass the error-term constraints that plague regression analysis with mixtures of discrete and

[1] For example Anand and Ravallion (1993) in studying the relationship between life expectancy and per capita GNP find that the latter variable loses its explanatory power when the incomes of the poor are entered as a separate variable.

continuous variables. Furthermore the approach circumvents the problems associated with establishing causality via conventional regression techniques with mixtures of discrete and continuous variables.

In this paper Section 1 considers the general issue of population weighting which impacts both issues, and outlines the technical background underlying both wellbeing improvement and dependence dominance approaches. Section 2 reports the results of various approaches and some conclusions are drawn in section 3. To anticipate our results and conclusions declines in polity over the earlier part of our observation period have been sufficient to outweigh the positive impact of the economic growth that was observed throughout the sample period so that overall wellbeing can be construed to have deteriorated over the early part of the period. The surge in the polity index in the latter part of the period restored overall wellbeing to the extent that wellbeing gains were made over the full sample period. With regard to causality the evidence is not especially strong but the causal effects of polity improvements on growth do seem to be greater than the causal effects of growth on polity improvements especially when the data are population weighted.

Section 1.

Representative Agents or Technology Blueprints: to weight or not to weight, that is the question?

It may be argued that fundamental notions of individualistic welfare underlay much of the work in this area in the sense that it is the wellbeing of individuals in poor societies that is of concern with respect to the lack of economic growth in those societies. In as much as this is the case and the models can be interpreted as representative agent models due consideration should be given to population weighting observations. The representative agent from China is actually representing well over 25% of the sample (global) population whereas the representative agent from Ireland is representing less than 1% and there is a strong argument that observations on those countries should be viewed accordingly. On the other hand if the Polity – Per capita GNP nexus is viewed as a technological relationship and each country realization is viewed as an observation on a particular technology blueprint so that interest is focused on the "average" technology the argument for population weighting is much weaker. Here both approaches are considered and, as will be seen, it appears to make a difference which suggests that scale is also an issue. Models that are linear in polity and per capita GNP presume a sort of homotheticity with respect to country scale reflected by population size, the fact that population weighting makes a difference suggests that this presumption is wrong (which will be a matter for future research).

Has Wellbeing in terms of Polity and Growth Increased?

When wellbeing is measured in terms of a combination of economic and political wellbeing, establishing an improvement in overall wellbeing is slightly more complicated if both do not advance together. This is so since advances in one dimension may or may not outweigh declines in another in terms of overall wellbeing, whether or not there has been an overall advance can be evaluated by employing Multivariate Stochastic Dominance techniques Anderson (2007), Duclos, Sahn and Younger (2006). These techniques do not provide a complete ordering of states however when they do provide a ranking the ordering is unambiguous. Suppose societal wellbeing in period i were a function $U(A_i,B_i)$ of economic wellbeing (A_i) and Political freedoms (B_i) with U being monotonic and non-decreasing in both arguments and constant across periods. Further let A_i and B_i be jointly distributed with pdf $f_i(A_i,B_i)$ and corresponding cdf $F_i(A_i,B_i)$, i = 1,2 (note the distribution may vary across periods). Specifically in the application herein A is a continuous variable and B is an integer in [1,7] so that;

$$f(A,B) = f_B(A)P(B),\ where\ B = 1,..,7,\ and\ -\infty < A < \infty$$
$$F(A,B) = \sum_{i=1}^{B} \int_{-\infty}^{A} f_i(X)P(i)dX,\ where\ B = 1,..,7,\ and\ -\infty < A < \infty$$

If $F_1(A,B) \leq F_2(A,B)$ for all pairs (A,B) with strict inequality holding somewhere then $E(U(A_1,B_1)) \geq E(U(A_2,B_2))$ and society 1 may be considered a welfare improvement over society 2 for all wellbeing functions in the monotonic non-decreasing family (Atkinson and Bourguignon(1982)). Given estimates of $F_1(A,B)$ and $F_2(A,B)$ their difference D = $F_1(A,B)$ - $F_2(A,B)$ may be calculated. If D is not significantly positive for all pairs A,B but is significantly negative for some pair A,B then $F_1(A,B)$ may be said to first order dominate $F_2(A,B)$ and $E(U(A_1,B_1)) \geq E(U(A_2,B_2))$.

This may be evaluated using the Kolmogorov-Smirnov statistic for differences between distributions applied to multivariate distributions. The statistic is based upon the maximum value of D over the support of the two distributions being compared where sample based estimates of the joint densities in two periods provide an estimate of maximum D[2]. The formula used for $(P(\sqrt{n}*D < \lambda)$ is $1\text{-}\exp(-2\lambda^2)$ which is Rayleigh's formula for the univariate statistic (K=1). Kiefer and Wolfowitz (1958) established the existence of a distribution function for the D's when K > 1 but found that generally it depended upon F. Kiefer(1961) revisited the bounds issue for situations where K > 1 and established a bound which suggests that the formula for the univariate case would provide conservative (i.e. larger) estimates of the true values when K > 1.

Causality Dominance.

Suppose y_t to be a vector of indices of economic wellbeing in period t with joint distribution $w(y_t)$, x_t to be a vector of indices of freedoms at period t with joint distribution $f(x_t)$ and $g(y_j,x_k)$ is the joint distribution of economic wellbeing in period j and freedom in period k. If wellbeing in period j and freedom in period k are independent then $g(y_j,x_k) = w(y_j)f(x_k)$ and

[2] The slight wrinkle here is that the joint distribution of the polity index and the gdp per capita describes a mixture of discrete (polity) and continuous (gdppc) variables. This does not pose a problem for sample cumulants are easily calculated.

$$0 < d(y_j, x_k) = 1 - \iint_{y,x} \min(g(y_j, x_k), \{w(y_j) f(x_k)\}) dydx < 1$$

is a measure of their dependence with values near one reflecting dependence. The term $\iint \min(g(y_j,x_k),\{w(y_j)f(x_k)\}dydx$ is a measure of the extent to which the unconstrained joint density of x and y and their density under independence of x and y overlap or coincide, it is a number between zero and 1.

In general for two continuous multivariate distributions $f_u(x)$ and $f_r(x)$ where x is an n dimensioned vector the overlap measure is defined as:

$$OV = \int_{-\infty}^{\infty} ... \int_{-\infty}^{\infty} \min(\mathrm{f_u}(\mathrm{x}), \mathrm{f_r}(\mathrm{x})) dx_1 ... dx_n$$

The distribution of OV has been fully developed in Anderson, Linton and Whang (2009) where defining the contact set, its compliments and corresponding probabilities as:

$$\begin{aligned} C_{f_p f_r} &= \{x \in R : f_u(x) = f_r(x) > 0\}; \quad p_0 = P(X \in C_{f_u f_r}) \\ C_{f_p} &= \{x : f_u(x) < f_r(x)\}; \quad p_u = P(X \in C_{f_u}) \\ C_{f_r} &= \{x : f_p(x) > f_r(x)\}; \quad p_r = P(X \in C_{f_r}) \end{aligned}$$

the kernel estimator of $\theta = \int \min(f_p(x),f_r(x))dx$ is shown to be normally distributed of the form:

$$\begin{aligned} &\sqrt{n}(\hat{\theta} - \theta) - a_n \Rightarrow N(0, v) \\ &where \\ &v = p_0 \sigma_0^2 + p_p(1 - p_p) + p_r(1 - p_r) \end{aligned}$$

where a_n and σ_0^2 are bias correction factors (see Anderson, Linton and Wang (2009) for details). The slight wrinkle here is that the vector x is a mixture of discrete and continuous variables x_d, and x_c respectively so that $x = (x_d, x_c)$ and the measure may be written as:

$$OV_{mix} = \int_{-\infty}^{\infty} \sum_{d} \min(\mathrm{f_u}(\mathrm{x}),\ \mathrm{f_r}(\mathrm{x}))dx_c$$

The OV measure for the discrete case has been developed in in Anderson, Ge and Leo (2009), OV_{mix} can be seen to be a mixture of the two cases.

Interest focuses on $d(y_{t-i},x_t)-d(y_t,x_{t-i})$ for i=1,..,n with consistent positive differences supporting the hypothesis that growth promotes freedom more than the reverse and negative differences supporting the idea that freedom promotes growth more-so than the reverse. Essentially conditions like $d(y_{t-i},x_t)-d(y_t,x_{t-i}) \geq 0$ for all i (or $d(y_{t-i},x_t)-d(y_t,x_{t-i}) \leq 0$ for all i are forms of dominance relationships and establishing them empirically would lend considerable support to one view or the other. The inequalities need to hold simultaneously thus simultaneous comparison techniques are appropriate (Wolak (1989), Stoline and Ury (1979)).

Results.

The issues of wellbeing improvement and causality dominance are examined by employing data on institutional quality (from the Polity IV project) and GNP per capita (from the World Bank) for 88 countries observed over a period of 40 years at 5 year intervals. Details of the data are reported in Appendix 1, summary statistics are presented in Tables 1 and 1a. With respect to the un- weighted statistics note that average polity declined over the first 15 years of the data and rose thereafter recovering its initial level after 25 years and subsequently continuing to rise to unprecedented levels. Growth in average gnp per capita was sustained throughout the period, though not in median gnp which saw a decline and then a recovery after 1985. The plight of the poorest nation improved through the 1990's and then declined substantially. With regard to the dispersion measure polity and gnp per capita appear to be driven by very different processes with the polity measure appearing to be a convergent measure whereas the gnp process appears to be a divergent measure. The population weighted statistics seem to tell a similar story with respect to the polity index though the GNP per capita results are very different with substantially less growth, substantially lower median values and greater dispersion.

Table 1.

	Means, Medians, Standard deviations, Maximums and Minimums									
	Polity Index					Gnp Per Capita.				
1960	4.0595	3	2.3865	7	1	2.8340	0.9360	3.8138	18.7110	0.0990
1965	3.9048	3	2.4079	7	1	3.4042	1.0250	4.6036	21.8770	0.1000
1970	3.5476	3	2.3867	7	1	4.1108	1.2265	5.4884	25.1250	0.1220
1975	3.4881	3	2.4909	7	1	4.7011	1.4135	6.1152	25.5950	0.1400
1980	3.7024	3	2.4971	7	1	5.2871	1.5490	6.9372	28.2060	0.1400
1985	4.0238	3	2.4690	7	1	5.6276	1.4660	7.6299	29.6870	0.1530
1990	4.6071	5	2.3593	7	1	6.2496	1.5100	8.6665	33.3690	0.1320
1995	5.0238	6	2.1055	7	1	6.7504	1.6780	9.2308	35.4390	0.0560
2000	5.2381	6	1.8860	7	1	7.7052	2.0165	10.572	37.4720	0.0850

Table 1a.

	Population Weighted Means, Medians and Standard deviations					
	Polity Index			Gnp Per Capita.		
1960	4.3159	3	2.4045	2.6032	0.1880	4.3386
1965	4.1409	3	2.4693	3.0737	0.1930	5.1541
1970	3.9913	3	2.4946	3.6255	0.2280	6.0631
1975	3.7311	2	2.3118	3.9241	0.2200	6.6360
1980	4.3024	3	2.3210	4.3216	0.2500	7.4917
1985	4.5155	3	2.2116	4.6062	0.2820	8.1715
1990	4.6626	3	2.1532	5.0420	0.3730	9.2744
1995	4.8433	5	2.0778	5.3339	0.5960	9.6872
2000	5.1097	6	1.8967	5.8958	0.8440	10.6937

Wellbeing Improvement?

Tables 2 -2b report the Kolmogorov-Smirnov first order Stochastic Dominance comparisons for all possible pairs of years in the sample. Unweighted, population weighted and population weighted excluding China and India are reported. The joint densities were estimated using the integral of the Epechinokov kernel in the continuous dimension with straightforward cumulation in the discrete dimension. A 0.05 critical value was employed to evaluate the null, if H_o: A dominates B was not rejected but H_o: B dominates A was then a welfare improvement from B to A was declared. If both were rejected or both were not rejected a no decision was declared.

It is interesting to note that the un-weighted results are by far the clearest (only 5/36 comparisons were indeterminate compared with 20/36 in the weighted distributions with China and India included and 10/36 in the weighted distributions with China and India excluded). Across all three comparison methods the results largely reflect the fact that declines in polity in the early part of the observation period, roughly from 1960 through to 1975, resulted in overall declines in wellbeing from the initial condition through to 1985. That is to say they outweighed progress in incomes that were a feature of the whole period. After 1985 those declines had been made up and the further progress that political freedoms made meant that unambiguous wellbeing improvements were sustained through to 2005.

Table 2.

Comparison Years (1 = 1960, 2 = 1965 etc.) A	B	Increase (↑), decline (↓) or indeterminate (nd) change (0.05 cv)	P(H_o: B first order dominates A)	P(H_o: A first order dominates B)
1.0000000	2.0000000	↓	0.026095697	0.11850338
1.0000000	3.0000000	nd	0.097916794	0.51465297
1.0000000	4.0000000	nd	0.20874747	0.60711409
1.0000000	5.0000000	↓	0.0082932073	0.47699463
1.0000000	6.0000000	↓	0.023747494	0.11571586
1.0000000	7.0000000	↑	0.51823675	0.019935707
1.0000000	8.0000000	↑	0.82367753	5.7875176e-007
1.0000000	9.0000000	↑	0.91784705	0.0059285395
2.0000000	3.0000000	↓	0.031452497	0.26554788
2.0000000	4.0000000	nd	0.12376443	0.45588410
2.0000000	5.0000000	↓	0.044379124	0.31831677
2.0000000	6.0000000	↑	0.10601742	0.026537624
2.0000000	7.0000000	↑	0.62963214	0.0061565362
2.0000000	8.0000000	↑	0.91564586	1.6200814e-007
2.0000000	9.0000000	↑	0.97356939	0.00062529422
3.0000000	4.0000000	↓	0.048017103	0.13007599
3.0000000	5.0000000	nd	0.11957484	0.058384074
3.0000000	6.0000000	↑	0.38634246	0.017977451
3.0000000	7.0000000	↑	0.90266393	0.0056174308
3.0000000	8.0000000	↑	0.98590375	8.7398894e-006
3.0000000	9.0000000	↑	0.99679388	2.2803319e-006
4.0000000	5.0000000	↑	0.11010568	1.0208946e-008
4.0000000	6.0000000	↑	0.46673230	0.00071125766
4.0000000	7.0000000	↑	0.87021908	7.7727105e-005
4.0000000	8.0000000	↑	0.98095379	3.5621253e-005
4.0000000	9.0000000	↑	0.99526916	2.1558126e-006
5.0000000	6.0000000	↑	0.19299481	0.0013534198
5.0000000	7.0000000	↑	0.75971296	7.4649073e-005
5.0000000	8.0000000	↑	0.95623359	1.0352316e-006
5.0000000	9.0000000	↑	0.98800982	6.4344415e-005
6.0000000	7.0000000	↑	0.44568735	5.7465243e-007
6.0000000	8.0000000	↑	0.84905464	2.1653034e-006
6.0000000	9.0000000	↑	0.94348564	6.8788149e-005
7.0000000	8.0000000	↑	0.30718239	5.1650570e-006
7.0000000	9.0000000	↑	0.55811598	2.6561361e-008
8.0000000	9.0000000	nd	0.16173100	0.056415134

Table 2a (population weighted including China and India).

Comparison Years (1 = 1960, 2=1965 etc.) A	B	Increase (↑), decline (↓) or indeterminate (nd) change (0.05 cv)	P(H_o: B first order dominates A)	P(H_o: A first order dominates B)
1.0000000	2.0000000	↓	0.012311067	0.10479906
1.0000000	3.0000000	↓	0.016197666	0.36370992
1.0000000	4.0000000	↓	0.00090649030	0.86721410
1.0000000	5.0000000	nd	0.059709774	0.69177442
1.0000000	6.0000000	nd	0.062985155	0.79529069
1.0000000	7.0000000	nd	0.11624084	0.95983110
1.0000000	8.0000000	nd	0.69358022	0.76415276
1.0000000	9.0000000	nd	0.55154715	0.95972809
2.0000000	3.0000000	↓	0.035547872	0.20920414
2.0000000	4.0000000	↓	0.011977133	0.83354021
2.0000000	5.0000000	↓	0.041373940	0.42731053
2.0000000	6.0000000	nd	0.11601445	0.64891922
2.0000000	7.0000000	nd	0.24593613	0.94230165
2.0000000	8.0000000	nd	0.68335991	0.76361940
2.0000000	9.0000000	nd	0.67281329	0.95025659
3.0000000	4.0000000	↓	6.6152341e-006	0.55386816
3.0000000	5.0000000	nd	0.099397583	0.15205695
3.0000000	6.0000000	nd	0.32242648	0.48926328
3.0000000	7.0000000	nd	0.45951041	0.90200906
3.0000000	8.0000000	nd	0.91483171	0.61934480
3.0000000	9.0000000	nd	0.89461235	0.89305615
4.0000000	5.0000000	↑	0.22337623	0.047758204
4.0000000	6.0000000	nd	0.51059764	0.33271108
4.0000000	7.0000000	nd	0.66370882	0.83829950
4.0000000	8.0000000	nd	0.97629449	0.48470411
4.0000000	9.0000000	nd	0.96875965	0.81907182
5.0000000	6.0000000	nd	0.13344319	0.15206811
5.0000000	7.0000000	nd	0.26213185	0.31874794
5.0000000	8.0000000	↑	0.64443631	2.1820664e-006
5.0000000	9.0000000	↑	0.68587293	1.3710790e-005
6.0000000	7.0000000	↑	0.030367266	0.049145457
6.0000000	8.0000000	↑	0.58521921	3.0951799e-006
6.0000000	9.0000000	↑	0.75671521	2.1950087e-005
7.0000000	8.0000000	↑	0.38950613	3.4595414e-007
7.0000000	9.0000000	↑	0.69725946	0.035595225
8.0000000	9.0000000	↑	0.34233381	0.0017220562

Table 2b (population weighted no China or India).

Comparison Years (1 = 1960, 2=1965 etc.) A	B	Increase (↑), decline (↓) or indeterminate (nd) change (0.05 cv)	P(H_o: B first order dominates A)	P(H_o: A first order dominates B)
1.0000000	2.0000000	nd	0.063238664	0.39408100
1.0000000	3.0000000	nd	0.20254125	0.63036076
1.0000000	4.0000000	nd	0.26718915	0.81810162
1.0000000	5.0000000	↓	0.0074026734	0.77089334
1.0000000	6.0000000	↓	0.047936564	0.26337816
1.0000000	7.0000000	nd	0.51987356	0.13901535
1.0000000	8.0000000	↑	0.69308651	0.00014329966
1.0000000	9.0000000	↑	0.85077586	0.039237850
2.0000000	3.0000000	nd	0.11239711	0.26011478
2.0000000	4.0000000	nd	0.087104918	0.50830041
2.0000000	5.0000000	nd	0.099218213	0.43648797
2.0000000	6.0000000	nd	0.35005223	0.096537349
2.0000000	7.0000000	↑	0.62676388	0.045879373
2.0000000	8.0000000	↑	0.82788121	5.9325521e-005
2.0000000	9.0000000	↑	0.96331337	0.0015408809
3.0000000	4.0000000	nd	0.0076207032	0.085633244
3.0000000	5.0000000	↓	0.010915308	0.063602252
3.0000000	6.0000000	↑	0.41551074	0.041262914
3.0000000	7.0000000	↑	0.68134139	0.015871029
3.0000000	8.0000000	↑	0.89700057	0.00018287109
3.0000000	9.0000000	↑	0.98747463	1.8514816e-006
4.0000000	5.0000000	↑	0.054535959	0.0014700837
4.0000000	6.0000000	↑	0.58623719	0.00029843225
4.0000000	7.0000000	↑	0.79959322	0.034869126
4.0000000	8.0000000	↑	0.95917695	0.00020264293
4.0000000	9.0000000	↑	0.98987974	3.0430335e-005
5.0000000	6.0000000	↑	0.40807978	0.00043506019
5.0000000	7.0000000	↑	0.66971880	1.3204289e-006
5.0000000	8.0000000	↑	0.91247128	7.1326197e-006
5.0000000	9.0000000	↑	0.98321602	5.0665324e-005
6.0000000	7.0000000	↑	0.10522856	8.7281870e-007
6.0000000	8.0000000	↑	0.56006106	1.1273375e-005
6.0000000	9.0000000	↑	0.87632965	7.9859118e-005
7.0000000	8.0000000	↑	0.23469919	0.00013157124
7.0000000	9.0000000	↑	0.80855281	3.5060235e-006
8.0000000	9.0000000	nd	0.61916063	0.056347152

In the population weighted results the presence of China and India have an overwhelming impact in increasing the extent to which no clear decision can be made, largely because their outcomes dominate the sample. When they are excluded from the sample the results return largely to those observed in the un-weighted comparisons though there is a greater deal of indeterminacy in the earlier part of the observation period largely because the recovery of the polity index is swifter in this paradigm.

Causality Dominance

Difficulties with the joint density estimation due to too few observations in some of the lowest polity categories meant that categories 1 and 2 were amalgamated as were categories 3 and 4 yielding a new polity scale from 1 to 5. Firstly dependence of GDP on past polity measures and dependence of polity on past GDP measures is readily established for all lags examined (0 to 40years in 5 year intervals) details are in the Appendix. Clearly causality runs in both directions, the question is does one direction dominate the other in the sense that the degree of dependence is always at least as great in one particular direction at every lag. Tables 3, 3a and 3b report the causality dominance results for the un-weighted, population weighted and population weighted excluding

Table 3. Causality Dominance Overlap Tests (y=incomes, x=institutions) Un-weighted

Lag length (years)	No Bias Adjustment				Bias Adjusted			
	$d(y_{t-i},x_t)$	$d(y_t,x_{t-i})$	"t(diff)"	P(T>"t")	$d(y_{t-I},x_t)$	$d(y_t,x_{t-i})$	"t(diff)"	P(T>"t")
0	0.4282	0.4291	-0.0139	0.4945	0.1485	0.2465	-0.9296	0.1763
5	0.4256	0.4342	-0.1943	0.4230	0.1754	0.2397	-0.8672	0.1929
10	0.4207	0.4216	-0.0235	0.4906	0.2043	0.2390	-0.5769	0.2820
15	0.4200	0.4162	0.1251	0.5498	0.2260	0.2411	-0.2855	0.3876
20	0.4286	0.4145	0.5233	0.6996	0.2482	0.2486	-0.0066	0.4974
25	0.4299	0.4203	0.3850	0.6499	0.2631	0.2597	0.0790	0.5315
30	0.4254	0.4237	0.0766	0.5305	0.2674	0.2699	-0.0606	0.4758
35	0.4169	0.4135	0.1730	0.5687	0.2671	0.2666	0.0126	0.5050
40	0.4242	0.4242	0.0000	0.5000	0.2819	0.2819	0.0000	0.5000

Table 3b. Causality Dominance Overlap Tests (y=incomes, x=institutions) Population weighted with India and China included

Lag length (years)	No Bias Adjustment				Bias Adjusted			
	$d(y_{t-i},x_t)$	$d(y_t,x_{t-i})$	"t(diff)"	P(T>"t")	$d(y_{t-I},x_t)$	$d(y_t,x_{t-i})$	"t(diff)"	P(T>"t")
0	0.4608	0.4443	0.2787	0.6098	0.2765	0.3087	-0.3026	0.3811
5	0.4509	0.4582	-0.1665	0.4339	0.2983	0.3312	-0.4411	0.3296
10	0.4346	0.4682	-0.9411	0.1733	0.2890	0.3595	-1.1777	0.1195
15	0.4434	0.4640	-0.6857	0.2464	0.3125	0.3560	-0.8374	0.2012
20	0.4492	0.4709	-0.8188	0.2064	0.3343	0.3730	-0.8418	0.2000
25	0.4562	0.4757	-0.8129	0.2081	0.3533	0.3854	-0.7642	0.2224
30	0.4636	0.4601	0.1601	0.5636	0.3702	0.3747	-0.1159	0.4539
35	0.4584	0.4542	0.2129	0.5843	0.3705	0.3708	-0.0101	0.4960
40	0.4513	0.4513	0.0000	0.5000	0.3689	0.3689	0.0000	0.5000

Table 3c. Causality Dominance Overlap Tests (y=incomes, x=institutions) Population weighted with India and China excluded

Lag length (years)	No Bias Adjustment				Bias Adjusted			
	$d(y_{t-i},x_t)$	$d(y_t,x_{t-i})$	"t(diff)"	P(T>"t")	$d(y_{t-i},x_t)$	$d(y_t,x_{t-i})$	"t(diff)"	P(T>"t")
0	0.4748	0.4724	0.0410	0.5163	0.3364	0.3458	-0.0873	0.4652
5	0.4554	0.4784	-0.5301	0.2980	0.3278	0.3798	-0.6922	0.2444
10	0.4436	0.4890	-1.2918	0.0982	0.3165	0.4005	-1.3924	0.0819
15	0.4454	0.4879	-1.4217	0.0776	0.3321	0.3961	-1.2303	0.1093
20	0.4546	0.4940	-1.4913	0.0679	0.3529	0.4053	-1.1296	0.1293
25	0.4629	0.4923	-1.2363	0.1082	0.3682	0.4058	-0.8906	0.1866
30	0.4713	0.4761	-0.2247	0.4111	0.3840	0.3940	-0.2550	0.3994
35	0.4663	0.4673	-0.0541	0.4784	0.3841	0.3888	-0.1271	0.4494
40	0.4655	0.4655	0.0000	0.5000	0.3879	0.3879	0.0000	0.5000

India and China data sets respectively. These results are based upon a discrete – continuous specification of the joint densities which employs a Gaussian kernel for the continuous component using Silvermans's rule of thumb for the window width[3]. Results are presented for both estimates which don't adjust for the estimation bias and estimates which do. The test statistics for the differences in dependence at each lag take account if the lack of independence between the two dependences (i.e. the standard errors of the difference are co-variance adjusted). With respect to the un-weighted results it is readily seen that there is a not an inconsequential degree of contemporaneous dependence between economic outcomes and institutions which diminishes as successive lags of incomes are related to current institutions but diminishes to a lesser extent when successive lags of institutions are related to current incomes. However none of the differences between income dependent upon polity and polity dependent upon income measures are significant.

The weighted sample results exhibit the same pattern though the level of dependency appears stronger in all cases. The hypothesis that the dependency of current economic outcomes on past institutions outweighs the dependency of current institutions on past economic outcomes cannot be rejected at any lag whereas the reverse hypothesis is rejected at modest levels of significance throughout the lag structure. As previously noted, population weighting in this sample attaches extraordinary weight to China and India data points, this essentially causes the results to be predominantly a reflection of the circumstances in those countries. If China and India are omitted from the sample a

[3] Silvermans rule of thumb for the window width is $1.06\sigma n^{-1/(4+k)}$.

somewhat stronger version of the story underlying the un-weighted data emerges with Polity causing growth more strongly dominating the growth causing polity story.

Conclusions.

There has been considerable debate as to which of economic growth and freedoms has priority in causing the other. In part the debate has been fomented by the fact that the two causality hypotheses are not mutually exclusive, it is not a case of establishing one or the other but more a case of establishing which "most" influences the other. Conventional regression techniques run in to some difficulties here, in the first instance they can only consider the issue of linear dependence between variables, secondly it is difficult to capture the nature of the two way relationship when one of the variables is limited in its range of variation (i.e. integer in nature). To facilitate examination of the polity growth relationship in this context a concept of dependence or causality dominance has been introduced. Using an adaptation of an overlap measure developed in Anderson et. al. (2009) as an index of the degree of statistical dependence between two variables x and y when one of them is integer it is possible to compare the degree of dependence (D(y,Lx)) of current y on past or lagged x (denoted Lx) with the degree of dependence of current x on past y (D(x,Ly)). If D(y,Lx) $\geq$ ($\leq$) D(x,Ly) for all L with strict inequality holding for some L, then x (y) may be said to causality dominate y (x).

A "polity" measure and GNP per capita to consider the standard growth regressions and the causality dominance relationship between growth and political freedoms across a sample of 84 countries over 5 year intervals spanning 1960 to 2000. The classic growth regression results were observed in that joint causality could not be rejected. There was some evidence of a unit root process in the polity variable but this is not surprising given its integer nature and the result did not stand when the data were population weighted. As for the causality dominance results substantive evidence was observed to support the notion that political freedoms foster increases in economic wellbeing to a greater extent than increases in wellbeing foster economic growth when the data are weighted by population size (consistent with an agent wellbeing interpretation of the model) and China and India are excluded from the calculus. When they were included the results still favoured the “freedoms dominate growth” hypothesis however the inferential basis was somewhat weaker. When the data were not population weighted (consistent with a technology interpretation of the income – polity relationship) the results were inconclusive.

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Appendix I: Data

1) Institutions Variable: *ExConst*
   - Constraints on the executive measured on a scale of 1 to 7 where 1 represents unlimited authority and 7 represents executive subordination. Higher values of *ExConst* therefore reflect better institutions.
   - Data from Polity IV Project (www.systemicpeace.org/inscr/inscr.htm). See Jaggers and Marshall (2007) for a description.
   - The Polity IV dataset does not report measures of executive constraints for transition years. This was an issue for a few of the observations used here and, to circumvent it, the closest available data point – usually within one or two years of the missing one – was used.
2) Economic Outcomes Variable: *GdpPc*
   - Real GDP per capita measured in thousands of constant 2000 US$.
   - Data from the World Bank's World Development Indicators database.
3) Population
   - Data from the World Bank's World Development Indicators database.

4)Countries

   - The following were chosen based on data availability for the period 1960–2005:

Algeria, Argentina, Australia, Austria, Belgium, Benin, Bolivia, Brazil, Burkina Faso, Cameroon, Canada, Central African Rep, Chad, Chile, China, Colombia, Congo Brazzaville, Congo Kinshasa, Costa Rica, Denmark, Dominican Rep, Ecuador, Egypt, El Salvador, Finland, France, Gabon, Ghana, Greece, Guatemala, Haiti, Honduras, Hungary, India, Indonesia, Iran, Ireland, Israel, Italy, Ivory Coast, Japan, Kenya, Liberia, Madagascar, Malawi, Malaysia, Mauritania, Mexico, Morocco, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Portugal, Rwanda, Senegal, Sierra Leone, Singapore, South Africa, South Korea, Spain, Sri Lanka, Sudan, Sweden, Switzerland, Syria, Thailand, Togo, Trinidad, Tunisia, United Kingdom, United States, Uruguay, Venezuela, Zambia.