How Do Institutions Lead Some Countries To Produce So Much More Output per Worker than Others?*

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1. Introduction

Development accounting exercises have established that the observed per capita income differences across countries are only partially explained by variations in production inputs.[i] Of these large (up to 36 fold) differences, about half are commonly attributed to a regression residual that Abramowitz termed "the economists' measure of ignorance." To capture the determinants of the sizable differences in residuals in turn, a voluminous empirical literature has emphasized the role of institutions. Cross-country regressions have shown that institutions are highly correlated with income per capita; and that institutions can explain up to 30 fold per capita income differences between developed and developing countries.[ii]

Previous empirical approaches to estimating the power of institutions in explaining per capita income rely on reduced forms, regressing output on institutions only. This method highlights the effect of institutions in a dramatic fashion, but sheds little light on the exact mechanics by which institutions actually affect output. Given the parsimonious set-up of the regressions, this approach may also substantially overestimate the effect of institutions on output. The purpose of this paper is to add detail to the popular reduced form estimations and examine different hypotheses regarding the exact mechanics by which institutions affect income per capita.

Institutions alone do not produce output. Hence, their effect must be indirect, operating either through their impact on factor accumulation or productivity. Hall and Jones (1999) suggest that just under half of the impact

of institutions on output is through their effect on factor accumulation, while the remainder is due to the impact of institutions on productivity. These results contrast with the results of Mankiw, Romer, and Weil (1992), which emphasize the importance of investment in human and physical capital.

In this paper we combine the approach of Hall and Jones (1999, HJ henceforth) with that of Mankiw, Romer, and Weil (1992, MRW henceforth) to explain cross country per capita income levels. Specifically, we examine whether specifications in which institutions are the sole determinant of output levels (as in HJ) can be improved upon by taking into account the effect of institutions on factor productivity. Our hypothesis is that the main contribution of institutional quality to development is through its impact on the accumulation of human and physical capital.

To explore our hypothesis we introduce factors of production into HJ's specification and institutions to the MRW setup. We find that the inclusion of a measure of institutions into the MRW specification does yield a significant coefficient on institutions and reduces the residual significantly. The estimates on human capital and physical capital do not change significantly.

Augmenting HJ's specification with physical factors of production reduces the effect of institutions on output by a whole order of magnitude. Institutions retain only about 15% of their explanatory power to account for cross country income levels as compared to the HJ results. This highlights that at least some part of the contribution of institutions to output might be institution-induced increases in physical factors of production.

Next we analyze exactly how institutions affect output via factor accumulation. Both HJ and MRW, assume that the elasticities of output with respect to inputs are constant across countries. Our hypothesis suggests, however, that the quality of institutions affects factor productivities and output shares. A test of the hypothesis shows that once we allow for the factor elasticities to vary across countries, the direct effect of institutions on output vanishes entirely and only the moderating effect of institutions prevails.

Institutions thus truly moderate the effect of human and physical capital on output. Interestingly enough, while better institutions increase the contribution of capital to output, the result is reversed for the case of human capital. Our results imply that while human capital and institutions by themselves contribute positively to output, institutions matter more for development in low human capital countries. Conversely, the better institutions are the less human capital matters in explaining differences in per capita income. These results indicate that, while physical capital and institutional quality are complements, human capital and institutions are substitutes in the development process.

Finally, we investigate the residual associated with each approach to measuring the effects of institutions on economic performance. Development accounting exercises have shown that a high correlation exists between the residual and per capita output. Due to this high correlation it seems natural to label the residual "productivity" or disembodied technology. Our results indicate, however, that by introducing institutions into the augmented Solow

development accounting framework, and allowing institutions to affect the productivity of factors largely eliminates any correlation of the residual with output. This returns the residual to a true econometric residual consisting simply of white noise.

2. Institutions and Output Levels

2.1. Development Accounting in the Absence of Institutions

Let us assume that output in country *i* is produced according to

$$Y_i = A_i K_i^{\alpha} H_i^{1-\alpha} \qquad (1)$$

where *K* denotes the stock of physical capital, *H* is the stock of efficiency units of labor, and *A* is a measure of labor-augmenting productivity. Defining all magnitudes in per capita terms, *y=Y/L*, *k=K/L*, and *h=H/L*, we can rewrite output per worker

$$\log y_i = \log A_i + \alpha \log k_i + (1-\alpha) \log h_i \qquad (2)$$

which highlights that per capita output depends on factor inputs and on the level of productivity.

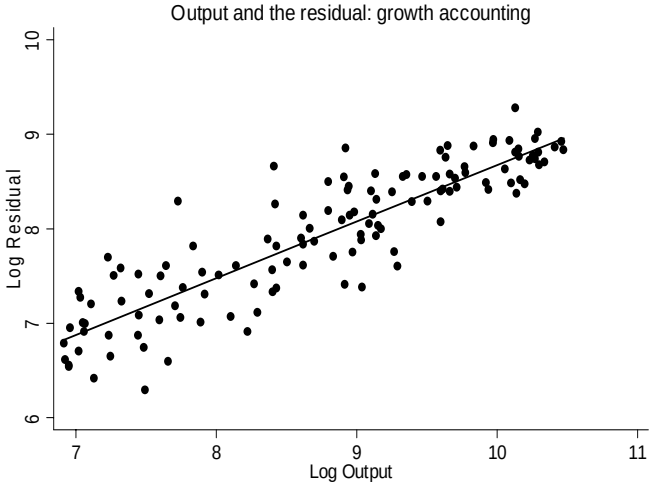
Hall and Jones (1999) analyze the power of factor inputs extensively to examine if additional factors, such as institutions, are required in order to understand any remaining, unexplained, cross-country income differences. In line with most previous work, their accounting exercise assumes the elasticity of output with respect to each input to be the same for all countries, and takes it to be equal to the value of the capital share in the US, that is, $\alpha = 1/3$. HJ then replicate the well known observation that differences in inputs explain only a

small fraction of cross-country differences in output. The Solow residual, obtained when we rewrite (2) as

$$\log A_i = \log y_i - \alpha \log k_i - (1-\alpha) \log h_i \qquad (3)$$

is in fact the main source of differences in per capita output across countries. Its correlation with per capita income is extremely high, as can be seen from figure 1, and differences in the residual explain almost 70 per cent of income differences across countries.

Figure 1
Output and the residual: growth accounting



2.2. The Role of Institutions in Development Accounting

The high correlation between the residual and per capita income has led to the interpretation that *A* is a measure of the level of technology in a country. Together with the results from the development accounting exercise described above, this implies that richer countries are richer because they use inputs more efficiently. Inspired by the work of North (1990), HJ hypothesize that a major determinant of aggregate productive efficiency in a country is the quality of its institutions.

Hall and Jones (1999) define a variable capturing the quality of institutions, which they call social infrastructure. It is a weighted average of five measures of government anti-diversion and a measure of openness to international trade. The correlation between the Solow residual and institutional quality is 0.60. Moreover, HJ maintain that institutions are in fact the fundamental determinant of a country's long-run economic performance, as they determine both productivity and factor accumulation. They argue that the econometric specification that identifies the impact of institutions on income takes the form

$$\log y_i = \gamma_0 + \gamma_1 I_i + \varepsilon \qquad (4)$$

where I is a measure of the quality of institutions or social infrastructure, which differs across countries, and ε is an error term. HJ estimate equation (4) and find that institutions can account for over 30-fold differences in per capita output.

2.3. Institutional Data and Endogeneity

Hall and Jones (1999) were not the first to examine the effects of institutions on economic performance. Keefer and Knack (1995 and 1997) provided early empirical analyses on the growth effects of institutions. Defining and measuring institutions is, however, not a straightforward matter, and the particular definition used may indeed influence the results. One of the novelties of the two papers by Keefer and Knack was to introduce better measures of the institutional framework countries. They suggested using subjective data, variables constructed from surveys and expert assessments such as

International Country Risk Guide (ICRG) and Business Environment Risk Intelligence (BERI).[iii] Variables such as contract enforceability, rule of law, or risk of expropriation, proved to be good proxies for the institutional setting.

The two most influential studies documenting the importance of institutions in explaining cross-country income difference, HJ and Acemoglu, Johnson and Robinson (2001), have used alternative measures of institutional quality. HJ focus on a hybrid between the earlier Keefer and Knack indices and the Sachs-Warner index of trade openness, whereas Acemoglu et al. measure institutions by the risk of expropriation.

A crucial concern when seeking to assess the effect of institutions on development is that the level of development itself also impacts the quality of institutions. Major efforts have been undertaken to search for good instruments to control for endogeneity. HJ and Acemoglu et al (2001) employ various correlates of Western European influence to instrument for their institutional variable.

The results in these papers have been confirmed by a number of subsequent studies,[iv] and the overall evidence is that institutions play an overwhelming role in explaining differences in economic performance across countries. However, the insights from these parsimonious approaches are still limited. Thus far, the literature has treated institutions as black boxes. Nevertheless, it is imperative to understand how institutions work to make countries more (less) productive, and how they impact upon and interact on factor accumulation. We attempt to address this question in the next section.

3. The Effect of Institutions versus Factor Accumulation

3.1. Combined Models of Institutions and Factors

The approach of HJ and Acemoglu et al (2001) contrasts sharply with the traditional methods used to identify the determinants of cross country per capita income, as in MRW who regress output per capita on factor inputs. Rather than using the value of the capital share in the US to account for the contributions of the various factors, MRW estimate the elasticities of the production function econometrically. In particular, they assume that output in country *i* is produced according to

$$Y_i = AK_i^{\alpha} H_i^{\beta} L_i^{1-\alpha-\beta} \tag{5}$$

where *L* denotes the number of workers. Given our definition of output per worker above and taking logs, we can re-express the above production function as

$$\log y_i = \log A + \alpha \log k_i + \beta \log h_i \tag{6}$$

The MRW approach is more general than the development accounting exercise in HJ, as it does not impose ex ante an elasticity of output, nor does it assume constant returns to accumulating factors. However, the crucial assumption in MRW is that all countries share identical productivities,[v] an assumption which does not seem to be supported by the results in HJ.

The first question we want to address is whether large differences in the residual remain, once we allow for the output elasticities to be determined by the data. MRW and HJ use somewhat different data, with the former using per

capita income for 1985 and secondary school enrolment rates as a measure of human capital, and the latter output per worker in 1988 and the stock of human capital. In order to render comparable results, we use the HJ output data in all specifications. Human Capital data are either the original MRW or HJ, again to generate comparable results.

Table 1
Institutions in the Augmented Solow Model

Dependent variable: log output per worker

	HJ	MRW	Combined model 1	Combined model 2
Institutions	5.142***		1.089***	.698**
	.343		.235	.249
Log h (enrolment rate)		.110	.099	
		.072	.069	
h (human capital stock)				.141
				.087
Log k		.603***	.525***	.562***
		.040	.048	.037
N	127	111	111	127
R-squared	0.58	0.91	0.92	0.91
Root MSE	0.70	.328	.31	.33
Correl (A, Y/L)	0.89	0.30	0.27	0.31
Correl (A, Institutions)	0.60	0.25	0.01	0.00

MRW specification without steady state assumptions. Specifications in columns 2 to 4 are two-stage least squares regressions, where institutions are instrumented as in HJ. Subscripts ***/**/* denote 1%/5%/10% significance levels.

Table 1 juxtaposes the basic empirical results. The first column reports the results of HJ, where institutions alone determine output levels. The second column presents a regression of output per capita on factor inputs, a general version of MRW. In their paper,[vi] MRW obtain a somewhat lower elasticity of output with respect to physical capital and a higher one for human capita, 0.48

and 0.23 respectively. However, the MRW estimates are within the 10% confidence interval implied by the estimates in column 2.

The last two lines of Table 1 report the correlation of the *residual* with output per capita and institutions for the two approaches. In the HJ set up, this is the Solow residual obtained from equation (3), for the MRW specification, it is the residual resulting from the regression equation. The augmented Solow model provides a very good fit for the data. In particular, the correlation between the residual and output levels drops from 0.89 to 0.30, indicating that the estimates for the elasticities of output give a much better picture than imposing $\alpha = 1/3$. Nevertheless, the resulting residual is still highly correlated with institutions (0.25).

The natural extension would be to combine the two insights and estimate a production function that includes both inputs and institutions. Suppose output is produced according to

$$Y_i = A_i K_i^{\alpha} H_i^{\beta} L_i^{1-\alpha-\beta} \tag{7}$$

with the level of productivity, A_i, being a function of institutions. In particular, we stipulate that

$$A_i = A e^{\delta I_i} \tag{8}$$

Output per capita is then a function of factor inputs, institutions and a residual, taken to be the level of technology, and we can express it as

$$\log y_i = \log A + \alpha \log k_i + \beta \log h_i + \delta I_i + \varepsilon \tag{9}$$

The third and fourth columns in Table 1 report the results of the combined model (9), using the secondary school enrolment rate as used by MRW, and the stock of human capital as calculated by HJ. Following HJ, we introduce institutions into the regressions without taking logarithms.

The results from the regressions are surprisingly good. All factors have the expected sign, and the estimates are quite robust across specifications. In particular, the coefficient on institutions is positive and significant, suggesting that HJ could have also included factors of production, or that MRW could have included institutional differences to derive a more accurate estimates of contributions of physical inputs to explaining per capita income differences across countries.

Once capital and labor are included in the regression, the estimate for the effect of institutions on growth, although still positive and significant, drops by a whole order of magnitude. Institutions can now account for only between 15 and 20 per cent of the variation in per capita incomes. At the same time, the inclusion of institutions shows that the elasticities of output with respect to human and physical capital barely change as compared to the basic MRW specification in column 1. These elasticities are somewhat lower in the specification with institutions.

Neither combined model represents a significant improvement over the specification of MRW in terms of the R^2. To assess the effectiveness of our specification, we examine how the combined models fare in terms of the Solow residual. The last two columns of Table 1 show that the inclusion of institutions

has an important effect: the correlation between the residual and output falls by 10 per cent (column 3), while the correlation between the residual and institutions entirely disappears. These correlations are also depicted in Figures 2 and 3.

Our specification thus purges the residual of its institutional component, rendering it a true statistical residual due to measurement errors or violations of the structural assumptions in the Solow growth accounting framework (such as constant returns to scale).

Figure 2

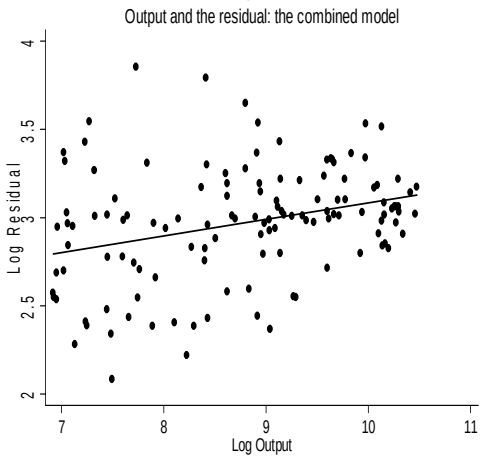
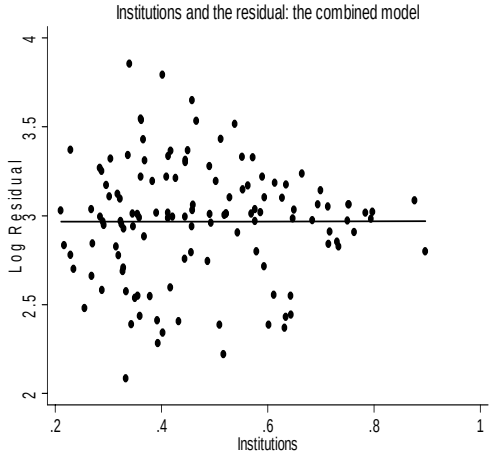


Figure 3



3.2. Direct and the Indirect Effects of Institutions

The regressions in Table 1 imply that both institutions and factor accumulation matter for output levels. However, institutions by themselves do not produce anything; their effect should actually be captured by the catalytic effect institutions have on the factors of production. In this section we seek to understand how much of the variation in output is accounted for by the direct

(and abstract) impact of institutions, as opposed to the indirect effect of institutions that works through factors inputs.

Table 2 reports the direct and indirect effects of institutions by regressing inputs on institutions. The indirect effects were obtained by running the regression x = $\gamma + \gamma_1 Institutions + \varepsilon$, where x is either k, h, or A. The direct effect of institutions is the coefficient δ (9), normalized such that the sum of coefficients is 5.142.

In row 1 we assess the contribution of inputs under the assumption that $\alpha = 1/3$, as in HJ. The contributions of inputs together with the residual, *A*, add to 5.142, which is the total contribution of institutions as measured by the coefficient in Table 1.

Table 2
Direct and Indirect Contributions of Institutions To Per Capita Income

	Dependent Variable				
	$\alpha \log \frac{K}{L}$	$\beta \log \frac{H}{L}^{*}$	$\log A$	Institutions	Combined Contribution of *H*, *K***
HJ	2.416	0.896	1.830		3.312
MRW	3.478	0.767	0.897		4.245
Combined model 1	3.745	0.325		1.072	4.070
Combined model 2	4.222	0.196		0.724	4.418

* *H* refers to MRW and HJ human capital variables, respectively, logged when necessary.
** Refers to the sum of columns 1 and 2. Coefficients in all intermediate regressions had significance levels of over 1%.

In the HJ specification in row 1, factors of production contribute about 64% to output, whereas the contribution of the Solow residual, *A*, accounts for the

remaining 36% of the variation in output levels across countries. That is, factor accumulation plays a limited role, accounting for less than two thirds of output differences, and institutions seem to mainly affect aggregate productivity.

The rest of the table repeats this exercise for the MRW augmented Solow model and of our combined models. The second line uses the production elasticities obtained by MRW, namely α=0.48 and β=0.23. With these elasticities, the role of factor accumulation becomes much more important: 82 per cent of the effect of institutions occurs through human and physical capital accumulation. Similar results are obtained when we use the elasticities obtained from the combined model. Again, the main role of institutions is to encourage factor accumulation, with the direct effect accounting for between 14 and 21 per cent of the overall impact.

The other major difference between the development accounting exercise and the results using estimated elasticities concerns the relative importance of physical and human capital accumulation. Imputing the value of α results in a contribution of institutions through human capital which is almost a third of the total contribution of factors. The augmented Solow model (with and without institutions) features a much more important effect through physical capital, with only a small effect occurring through human capital accumulation (between 4 and 18 per cent of the total contribution of factors).

3.3. The Interaction Between Institutions and Factors of Production

Our discussion above implies that physical and human capital react rather differently to improvements in institutional quality. A reason for this could be that the elasticities of output with respect to factor endowments, and hence factor returns, depend on a country's institutional quality. That is, given the level of technology, the effect of a given stock of (physical or human) capital on output depends on the quality of a country's institutions.

While MRW assume the level of technology to be common across countries and allow the output elasticities to be determined by the data, HJ impute the elasticities and allow technology to vary across countries. What both approaches share is the assumption that *factor shares are constant across countries*. Yet, the data cast doubt on this assumption. A number of recent studies document the extensive differences in factor shares across countries and over time (see Gollin, 2002, Harrison, 2002, and Bentolila and Saint-Paul, 2003). Such evidence raises the question of whether allowing the output elasticities to vary across countries can improve our understanding of income differences. If we assume that the elasticity of output with respect to the various inputs differs systematically across countries, we must propose a mechanism by which such differences arise. Here we stipulate that institutions crucially affect the productivity of factors and their shares in output.

In order to estimate the extent to which differences in output elasticities are driven by institutional differences, we further modify the production function used by MRW, and assume that output in country *i* is produced according to

$$Y_i = A_i K_i^{\alpha_i} H_i^{\beta_i} L_i^{1-\alpha_i-\beta_i} \qquad (10)$$

We propose that both the level of aggregate productivity and the elasticities of output with respect to the two inputs depend on the quality of institutions, *I*. As before, productivity is given by $A_i = Ae^{\delta I_i}$. Concerning the elasticities we assume a simple linear formulation, whereby $\alpha_i = a + \alpha I_i$ and $\beta_i = b + \beta I_i$. We can then write output per capita as

$$\log y_i = \gamma_0 + \gamma_1 I_i + \gamma_2 \log k_i + \gamma_3 I_i \log k_i + \gamma_4 \log h_i + \gamma_5 I_i \log h_i \qquad (11)$$

with institutions affecting output through γ_1, γ_3 and γ_5, which capture both the direct effect of institutions on TFP, which is constant across countries, as well as the effect of institutions on the input elasticities.

Table 3 reports the results of the estimation. Two surprising results emerge. First, the coefficient γ_1 is insignificant in both specifications. Institutions no longer affect total factor productivity, which contrasts with the results in Table 1. Rather, the effect of institutions on output is now entirely captured by its effect on the productivity of inputs. The alternative interpretation is that the HJ specification looses its validity once the effect of institutions on factor inputs and factor shares has been included. The second result is no less surprising: better institutions seem to increase the productivity of physical capital, but *reduce* that of human capital. Institutions increase the elasticity of output with respect to physical capital and labor, and reduce the elasticity with respect to human capital. Human capital and institutions by themselves have a positive impact, however institutions matter more for

growth in low human capital countries. The reverse way of thinking about this relationship is that the more human capital a country has, the less important institutions are.

Table 3
Institutional Effects on Labor and Capital Productivities

Dependent Variable: output per worker (2SLS)

	Augmented model 1	Augmented model 2
Institutions	-.036	-1.376
	1.679	1.705
Log k	.438***	.367***
	.095	.089
Institutions*Log k	.206	.471**
	.200	.210
Log h (enrolment rate)	.300*	
	.161	
Institutions*Log h	-.514	
	.396	
h (human capital stock)		.776**
		.310
Institutions*h		-1.297**
		.517
N	111	127
R-squared	0.93	0.91
Root MSE	.31	.33
Correl (A, Y/L)	0.27	0.30
Correl (A, Institutions)	0.00	0.00

HJ and MRW specifications instrumented for institutions as in HJ. Subscripts ***/**/* denote 1%/5%/10% significance levels.

Our results suggest that institutions and physical capital are complements. On the other hand, institutions and human capital are substitutes, in the sense that, given the stock of capital, a certain level of output can be produced either with good institutions and low human capital, or with poor institutions but a very educated labor force.

4. Conclusions

In this paper we provide a preliminary exploration of how institutions may directly affect per capita output. Our results indicate that the largest impact of institutions is through its effect on the factor productivity. While institutions have uniformly positive effects on the productivity of physical capital, our regressions indicate that institutions and human capital are substitutes. This can be interpreted as saying that institutions matter most for countries with low levels of human capital and least for those with high levels of educational attainment.

Two main implications emerge. First, the results provide evidence for an overinvestment in human capital in some countries, raising the question of whether traditional justifications for public provision of education, based on a high social return to education, are still valid. Second, they indicate that –in contrast to the HJ approach- that improving institutions is not sufficient to generate increases in income levels. Since the main role of institutions is to increase the productivity of capital, improving institutions in countries with a very low level of investment will have only a small impact on output.

Lastly, our analysis has been static. Yet the results have important dynamic consequences. If better institutions increase the productivity of capital, they will create investment incentives, and hence foster future output. In fact this could be a possible explanation for the strong correlation between physical capital and institutions found in the data.

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Endnotes

[i] See Caselli (2003) for a recent survey of development accounting.

[ii] See Knack and Keefer (1995 and 1997), HJ (1999), Acemoglu, Johnson and Robinson (2001 and 2002), Easterly and Levine (2002).

[iii] Before Knack and Keefer (1995 and 1997), secure property rights/good institutions were proxied by the Gastil Index of political and civil liberties, and frequency of revolutions, coups, and political assassinations. However, results from such regressions were less satisfactory.

[iv] See, amongst others, Kaufman et al. (1999), Easterly and Levine (2002), Grigorian and Martinez (2002) and Rodrik, Subramanian and Trebbi (2002).

[v] In their specification of the output levels regression equation, MRW also assume that all countries are in their steady state, and write the level of output as a function of investment shares, which in turn determine the steady state levels of human and physical capital. Our formulation is more general, and simply uses factor endowments as the determinants of income levels.

[vi] The coefficients we report are implied by the growth regressions in MRW which take into account that economies may not be at their steady states.