Institutions and their Measures: A Black Box of Goodies

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April 6, 2006

Abstract

The use of institutional measures in empirical work is widespread, but the question of what these measures actually capture and how they are constructed is something that is not given enough attention. Institutions and their measures are therefore like a "black box of goodies": Something that we do not know much about but at the same time is given a very prominent role in explaining economic development. This paper is an attempt to deepen our understanding of institutional measures by critically examining four measures that have been given a prominent role in the recent literature on economic development.

JEL classifications: B40; C82; P48.
Keywords: Institutions; Measurement; Methodology.

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1. Introduction

One of the most favored explanations of economic development is the presence of high quality institutions. The importance of "good" institutions is something that almost everyone in academia can agree on, but what institutions really are and how they are measured is something that we do not know much about. Institutions and their measures are therefore like a "black box of goodies" that we do not know much about, but at the same time is given a very prominent role in explaining why some countries are rich and others are poor.

The questions we should be asking are: How precise are the institutional measures, what do they actually measure and how similar are they? To be more specific, a popular measure in the empirical literature for institutions is "Expropriation Risk", which is used in influential papers such as for example Acemoglu et al (2001, 2002), Acemoglu and Johnson (2003), and Osili and Paulson (2004). This measure was originally used as one of the components of a measure constructed by Knack and Keefer (1995) and is also used by Hall and Jones (1999) in the construction of their measure "Social Infrastructure". The question that comes to mind is: Why is this measures so popular? Is it because it captures the meaning of institutions in an intuitive and convincing way or is it because the measure correlates highly with the desired variables? The validity of institutional measures is something that is often questioned, but seldom fully investigated.

Previous research which critically examines different institutional measures is surprisingly meager and consists, to my knowledge, only of Heckelman (2002), Hanke and Walters (1997), and Knack and Keefer (1995). If we compare the number of papers that examine and compare different institutional measures with the number of papers that use these measures to explain income or growth differences around the globe, those numbers simply do not match. This paper attempts to fill this gap and deepen our understanding of institutional measures by critically examining four measures that have had a large impact on how effects of institutions on income and growth across countries has been perceived. The four measures that are going to be examined are: Expropriation Risk used by Acemoglu et al (2001); Social Infrastructure from Hall and Jones (1999); the Fraser Institute measure Economic Freedom of the World, used by for example La

Porta et al (2002); and the Freedom House index Political Freedom and Civic Rights used in for example Barro and Sala-i-Martin (1995). These measures are not only used in these influential papers mentioned above, they are probably also amongst the most popular measures that are used in empirical research on economic development[1].

The questions to be addressed are: How are these measures constructed, what are they supposed to capture and how similar are they? A substantial part of this paper therefore examines the construction of the different measures. As will be shown, the understanding of institutional measures is greatly assisted by asking three simple questions: What type of measure is this, who provides this measure and for what, and finally, how specialized is this measure? These three simple questions give a deeper understanding of what the measures *actually* capture instead of just what they are *supposed* to capture. The institutional measures are also being compared statistically. Firstly, how correlated the different institutional measures are with each other, and secondly, how correlated the institutional measures are with GDP per capita and the Human Development Index. For the relation between income and institutional measures, a method for identifying outliers has also been implemented.

There are two main contributions of this paper: firstly, it provides an understanding of institutional measures in general, and secondly, the paper provides a critical examination of the four probably most influential measures of institutional quality.

The paper is organized as follows: Section 2 presents a short introduction to institutions as emphasized by North (1996). Section 3 presents the four institutional measures and discuss how they are constructed. Section 4 compares the measures statistically, followed by section 5 which summarize and draws conclusion.

[1] More than 140 published papers have used the Fraser institute measure (see http://www.freetheworld.com/papers.html for a listing of these papers). Expropriation risk was also recently used in Osili and Paulson (2004), and Social Infrastructure was recentely used in Persson (2005).

2. A Definition of Institutions

One of the most influential persons in the institutions literature is the Noble laureate Douglass C. North. The reason for North's popularity is probably because his discussion of institutions is clear and intuitively appealing. In North's definition of institutions there are two important distinctions. The first of these is between institutions and organizations. Consider the following statement.

> *It is the interaction between institutions and organisations that shapes the institutional evolution of an economy. If institutions are the rules of the game, organizations and their entrepreneurs are the players.*
> *(North, 1996, p. 345)*

There is here an important distinction between institutions and organizations, where organizations in this context are: Political bodies (political parties, councils etc), economic bodies (firms, trade unions etc), social bodies (churches, clubs etc), and educational bodies (schools and universities). Institutions are then the key determinant of what kind of organizations a society develops. The organizations will reflect the opportunities provided by the institutional framework; if the institutional framework promotes corruption, the organizations will be corrupt.

The institutional framework seems here to be very important, but the definition of institutions so far only consists of "the rules of the game". It is here that North makes his second important distinction; a distinction between formal and informal constraints:

> *Institutions are the humanly devised constraints that structure human interaction. They are made up of formal constraints (rules, laws, constitutions), informal constraints (norms of behavior, conventions, and self imposed codes of conduct), and their enforcement characteristics. Together they define the incentive structure of societies and specifically economies. (North, 1996, p. 344)*

The differences between formal constraints (rules) and informal constraints (norms) are interesting. The maybe most important difference is that rules can easily be changed, but norms cannot. Norms are said to give “legitimacy” to the rules. Since it is the norms that give legitimacy to the rules, a society that adopts the rules of another country will not necessarily experience the same economic performance, due to differences in norms. This is because the most important enforcement of the rules is through the self-enforcing codes of behavior, norms and values. In order for the rules to have their desired effect, the underlying norms and values have to change in accordance with the rules. This change can however be a very lengthy process. The norms of a society have an even more dominant and important role then the presence of formal rules only (North, 1986, 1996). The discussion and interpretation of North motivates the following figure of plausible causal linkages:

>>Figure 1 about here<<

Institutions are made up of informal and formal rules (norms and rules) where the informal rules determine the formal rules. It is then the informal and formal rules that together shape the behavior of organizations which help to determine economic performance.

3. Institutional Measures

3.1. Aspects of Institutional Measures

To get a first general understanding of institutional measures, it is informative to do a simple classification into three different aspects:

- Type of measure: Subjective or objective
- Provider of measure: Business or non-business
- Specialization of measure: General or specific

In a subjective measure the indexation has usually been subjectively constructed by a group of people who simply assigns a value based on country reports, news and other information. The values assigned by each member of this group are then gathered and form a sort of "consensus ranking". In an "objective" measure, the rankings of institutional quality are usually determined by a number of data sources, for example income data. Nonetheless, the included factors are decided upon by a group of people, and are thus to some degree also subjective. The distinction is that the more objective rankings are based on external data sources, whilst in the more subjective ranking the ranking itself is determined by a group of people.

An examination of a subjective measure is more a question of placing judgment on different people. This examination can be hard since the subjective ranking is more a potpourri of different people's expectations, feelings, and beliefs. Another problem with a subjective measure is that they often are on an ordinal instead of an interval or ratio scale, making the difference between rankings in the same measure hard to evaluate. All institutional measures examined in this paper have at least some subjective part. An examination of an objective measure is often more easily carried out, since it is more a question of placing judgment on the different sources used. Although one could still question the guidelines of the objective measure, which are given by a group of people.

The second classification, the provider of the measure, is divided into two main groups: Businesses and non-business. Businesses that provide institutional measures

usually create the measure for investors to be used to make investment decisions. For a non-business, which is typically an organization or a group of researchers, it is usually harder to figure out the intended use of the measure. For organization it is not uncommon that the measures are constructed for political and/or ideological reasons. The provider of the measure together with its intended use can therefore completely alter the composition and appropriateness of a measure.

The third aspect has to do with the degree of specialization, if the measure is very general or more focused and specialized. A measure that is “general” covers a wide range of aspects and types of institutional quality. A specific measure covers only one or a very limited number of aspects. A specialized measure might then be too specific and therefore miss other important aspects. With the somewhat abstract definition of institutions (as discussed in section two) it might seem natural to construct an institutional measure which covers a wide area of aspects. But this complicates the interpretation of the measure. What does it actually mean when a country receives a certain ranking? Because of the many aspects covered, the ranking given might be very “good” in some respect, but very “bad” in some other respect. The more detailed nuances might be missed. Moreover, two countries that are institutionally very different can seem very similar when evaluated at the “average”. Furthermore, as commented by Romer (2001, p.148), because the definition of institutions is very broad, the usage of these measures does not deliver anything approaching precise predictions about what characteristics are important, and therefore give little guidance for policymaking.

These three aspects (type, provider and specialization) is a rough but enlightening classification of institutional measures in general. In section 3.3, the four measures under examination will be classified accordingly. As for now, a description of the four institutional measures follows.

3.2. The Four Institutional Measures

3.2.1. Social Infrastructure and Expropriation Risk

The measures Social Infrastructure used in Hall and Jones (1999) and Expropriation Risk used in Acemoglu et al (2001) are closely related. Social Infrastructure consists of a measure for government antidiversion policies (GADP), combined with a measure for trade openness. The GADP is created almost identically to a measure called ICRG used in Knack and Keefer (1995) and consists of five categories: (i) Law and Order, (ii) Bureaucratic Quality, (iii) Corruption, (iv) Risk of Expropriation, and (v) Government Repudiation of Contracts[2]. The fourth category in the GADP, Risk of Expropriation, is the same as has been used by Acemoglu et al (2001). The two measures, Social Infrastructure and Expropriation Risk, therefore both originate from Knack and Keefer (1995).

Knack and Keefer

The purpose of Knack and Keefer (1995) was to use alternative measures of institutions in order to explain economic performance. Knack and Keefer argued that the measures that were being used at that time, the Freedom House index (referred to as the Gastil Freedom index), as well as the measures "Assassinations" and "Revolutions and Coups" used foremost by Barro (1991), were mere measures of political instability instead of institutions like property rights. Knack and Keefer therefore constructed two alternative measures using data from two firms that specialize in providing assessments of risks to international investors: Business Environmental Risk Intelligence (BERI), and the International Country Risk Guide (ICRG). With data provided from the International Country Risk Guide, Knack and Keefer construct the measure ICRG by summing up the categories mentioned above. The motivation for the use of the ICRG data is that it gives more detailed information "for large samples on disaggregated dimensions of property

[2] The GADP and ICRG are "almost identical" in the sense that they use the same components provided by the same source, the Political Risk Services. But the aggregation has been implemented differently. Hall and Jones (1999) use the average of the five categories mentioned above for the years 1986 to 1995. Knack and Keefer (1995) use the sum of these five categories for the first available data point, which is the year 1982 for "most" countries, 1984 for "some" countries, and 1985 for "a few" countries. What is meant more exactly by "most", "some", and "a few" is not explicitly described (Knack and Keefer, 1995, p226).

rights that are closely related to those institutions emphasized by for example North" (Knack and Keefer, 1995, p. 210).

By empirical testing, Knack and Keefer conclude that institutions that protect property rights are crucial to economic growth and that the ICRG measure is superior to the measures having been used previously (the political instability measures and the Freedom House index). This conclusion was based first of all on that the ICRG components are all closely related to those institutions emphasized by North (1990), and secondly that the ICRG was found to be highly correlated to economic growth. There is however one problem with the empirical analysis in Knack and Keefer (1995). Due to data limitations, "most" countries have data for the year 1982, where "some" for 1984, and a "few" for 1985. The institutional quality of the year 1982, 1984 and 1985 is then used to explain the GDP per capita growth over the period 1974 to 1989. By matching the years in this manner makes it ambiguous to interpret if institutions caused growth, or if it was the other way around[3]. Despite these endogeneity concerns, the results in Knack and Keefer had a huge impact and influenced several papers, especially Hall and Jones (1999) and Acemoglu et al (2001) in their choice of institutional measures.

International Country Risk Guide

The components that were used to form the ICRG in Knack and Keefer (1995) were constructed by the company International Country Risk Group. This company is now part of the company Political Risk Services (also called the PRS group) which is based in Syracuse, NY, USA. The PRS group specializes in providing information primarily *for* investors and businesses, about risks faced *by* businesses that operate at the international market. The PRS group provides detailed country specific reports as well as comparable indexes of political, economic and financial risks, where the indexes are complemented by detailed country specific reports.

[3] The reasons why Knack and Keefer (1995) match the years in this manner are first of all due to data availability. Knack and Keefer (1995, p. 215) also argue that since the evaluators might be influenced by the current levels of income in the countries they evaluate, and that current levels of GDP are naturally a product of past growth, estimates of property rights on growth might be biased upwards, and by matching the years in this way, it will reduce problems of simultaneity that might cloud inferences about the effect of property rights on growth. See also footnote 2.

The International Country Risk Guide rating (ICRG) consists of a group of analysts located in the United Kingdom. Each analyst is assigned a specific region, which he/she collects information about and then evaluates. The whole team is then gathered at a monthly meeting where the ratings are finally decided upon. An interesting fact is that the information and data on which the ratings for the ICRG are determined by are also available to the user. This enables the end user of the ICRG rating to form his/her own interpretation of the information and data against that of the ICRG staff. The ICRG index is divided into political, economical, and financial risks, where there are several sub-indexes of each risk area. It was from the political risks area that Stephen Knack constructed the index that is used in Knack and Keefer (1995).

The methodology for the ICRG ratings partly changed 1997 for two reasons: (1) To base more rating assessment on actual data in order to form a more objective assessment, which was now possible by better national and international reporting of data. (2) To better reflect the changed reality following the break up of the Soviet Union. The variable Expropriation Risk was affected by the later of these methodological changes. The Expropriation Risk variable is similar to another variable named Repudiation of Contracts (that is governments that default on contractual commitments), where expropriation can be seen as the worst case of this default. However, because the former communist states had no foreign direct investment, there could be no expropriation. Therefore, "Repudiation of Contracts" was mainly for the communist states and "Expropriation Risk" for the non-communist states. Following the collapse of the Soviet Union, there was no longer a reason for maintaining the distinction between "expropriation" and "repudiation", and the two measures were instead combined into the single risk component named "Contract Viability". Furthermore, because of the growing importance of globalization and inward investment, the risk of outright expropriation was considered lower than before. The weight on Contract Viability in the overall ICRG rating was therefore also reduced.[4]

[4] See http://www.prsgroup.com/index.html. Some of this information is also based on a telephone conversation with Nora Ruthig, Client services and sales at the PRS group, 6th of May 2004, and from email correspondence with the ICRG editor Tom Sealy.

Acemoglu, Johnson, and Robinson

Acemoglu et al (2001) use the variable Expropriation Risk since they ultimately want to focus on property rights and checks against government power. In the working paper version of that paper (Acemoglu et al, 2000) it is shown that the results are also robust to various other institutional measures[5]. Acemoglu et al (2000, 2001) also instrument the institutional variable, which should further increase our confidence in their results. These two actions, using alternative institutional measures, and IV-estimation, are recommendable when using institutional measures.

It is interesting to note, however, that the variable Expropriation Risk is no longer provided by the PRS group. Expropriation Risk and Repudiation has instead been combined into the variable Contract Viability. It seems as if the variable Expropriation Risk has established itself in empirical research and is recognized by researchers, which explains the variable's popularity. Although the variable Contract Viability is more up-to-date, it does not seem to be as recognized in academic research. It is also interesting to note that Contract Viability is given less weight in the overall ranking by the PRS group. Although Acemoglu et al (2001), among others, focus primarily on Expropriation Risk, it is given less weight by the PRS group, which deals professionally with risk assessments for investors. This leaves us with two concluding remarks: First of all, is Expropriation Risk still an important variable, or should focus instead be somewhere else? Secondly, if there still is a desire to measure expropriation, the variable Contract Viability should be a more up-to-date choice.

Hall and Jones

As mentioned earlier, Social Infrastructure in Hall and Jones (1999) is constructed by two components: government antidiversion policies (GADP) following Knack and Keefer (1995), and a measure of trade openness from Sachs and Warner (1995). GADP is the average of the five characteristics in the ICRG used by Knack and Keefer, over the years 1986-1995. The second component is a measure for openness constructed by Sachs and Warner (1995) and is the fraction of years during the period 1950-1994 that the country

[5] The other institutional variables are: Constraint on Executive 1970, 1990 (Polity III), Law and Order 1995 (PRS group), Property Rights 1997 (Heritage foundation), Rule of Law 1995 (Fraser Institute), and Efficiency of Judiciary 1980-83 (Business International).

has been classified as "open" and is measured on a 0 to 1 scale. The Sachs and Warner (1995) openness classification is based on five categories: (i) Non-Tariff Barriers, (ii) Tariffs, (iii) Black Market Premium, (iv) Socialist Economy, and (v) if the country had a State Monopoly on major exports or not.

The Sachs and Warner index has been heavily criticized by Harrison and Hanson (1999) and Rodriguez and Rodrik (2000) who found that the index is completely driven by two of its components: State Monopoly of Exports, and Black Market Premium. Moreover, these two components were argued to have very little to do with measuring openness. State Monopoly of Exports is simply to be a dummy for sub-Saharan Africa, which follows naturally since the source used only considers certain African countries. The other component (Black Market Premium) is argued by Rodriguez and Rodrik to be a less important determinant of openness and instead be an indicator for political and macroeconomic imbalance. By disaggregating the Sachs and Warner (1995) openness index into its sub-components, both in real values, as in Harrison and Hanson (1999), and into its dummy specification, as in Rodriguez and Rodrik (2000), it is demonstrated that it is in fact State Monopoly of Exports and Black Market Premium which drives the whole relation between the openness measure and income. It is therefore argued by Rodriguez and Rodrik (2000, p.291) that the Sachs and Warner openness measure is constructed to be a "super variable" that will be "statistically stronger than either African dummies or macroeconomic and political controls, because it jointly groups information from both."[6]

To sum up; Hall and Jones (1999) use the ICRG data, which is shown to be statistically very strong in Knack and Keefer (which suffered from endogeneity concerns), with the Sachs and Warner openness measure (which is heavily criticized by Rodriguez and Rodrik (2000) to be constructed as a "super variable"). Therefore, if we were to view this critically it would seems as if one "super variable" is combined with another "super variable" to construct the "super-super variable" for Social Infrastructure.

[6]Hall and Jones (1999) use the Sachs and Warner (1995) data which provide the fraction of years being opened. The Harrison and Hanson (1999), Rodriguez and Rodrik (2000) critic are mainly aimed at the Sachs and Warner (1995) openness dummy. Both measures are constructed similarly with the same type of components. The Rodriguez and Rodrik critic is therefore still valid. This fact is also commented by Romer (2001, p.146n).

3.2.2. The Fraser Institute's Economic Freedom of the World

The third measure under examination is supplied by the Fraser Institute. The Fraser institute is located in Vancouver, Canada, and describes itself to be an international forum for policy ideas and an independent public policy organization that focuses on the role competitive markets play in providing economic and social well-being for all Canadians. The institute is entirely funded by contributions from members and by sale of publications. Among other things, the Fraser institute publishes an index called: Economic Freedom of the World (hereafter called the Fraser EFW).[7]

The development of the Fraser EFW started in 1986 when Michael Walker from the Fraser institute and Milton Friedman hosted a series of conferences that focused on how to measure economic freedom. The version of the index that will be examined in this paper (Gwartney and Lawson, 2004) covers 123 countries and consists of five major areas: (1) Size of Government; (2) Legal System and Property Rights; (3) Access to Sound Money; (4) Freedom to Trade with Foreigners; and (5) Regulation of Credit, Labor and Business. Each area consists of subgroups where the total number of sub-components adds up to 38 different pieces of data. The sub-components ratings within each area are averaged to derive the ratings for each of the five areas. The summary index is then the average of the five areas.

A striking feature of this index is that it is not completely based on rankings by individuals. World Development Indicators as well as Government Finance Statistics, and International Financial Statistics from the World Bank and the International Monetary Fund are used. The subjective part is foremost taken from the Global Competitiveness Report, provided by the World Economic Forum. But components from the International Country Risk Guide provided by the PRS group are also used. An interesting fact is also that in the recent update of the EFW index, data from Kaufmann et al (2002) has been used to "fill in the gaps" where the usual data source was missing.

When evaluating the Fraser EFW, one has to remember what the Fraser institute stands for and that the EFW is a measure of specifically *economic* freedom. The Fraser EFW has a more political agenda, where the term economic freedom not only means protection of property rights and independent courts, but also means limiting the power

[7] For more information, see http://www.fraserinstitute.ca

and influence of the government, and keeping worker's rights at a minimum. In the Fraser EFW, government consumption as well as transfers and subsidies are seen as something that naturally retards economic freedom. Labor market regulations should allow market forces to totally determine wages and firing practices. For example; countries where the minimum wage had a small impact and/or was not strongly enforced received a high rating, which constitutes high economic freedom (Gwartney and Lawson, 2004, p.10). Therefore the index seems to be constructed in order to motivate the policy ideas of the Fraser institute[8]. The question is then if this is what we want to mean by economic freedom and institutional quality? The Fraser measure is a perfect example of why it is important to ask who is providing the measure and for what. Moreover, the EFW index also seems to be constructed in order to explain economic performance. In the report by Gwartney and Lawson (2004) describing the index, there is a special section that demonstrates how well the aggregate index correlates with income growth.

Although one does not have to agree with the views of the Fraser Institute, the EFW dataset is freely provided over the internet and for later years the dataset also contains detailed data on the sub-components, which makes the dataset still useable.[9]

3.2.3. The Freedom House Index

The fourth measure under examination is constructed by the Freedom House organization. Freedom House describes itself as a clear voice for democracy and freedom around the world. Freedom House is a non-profit, nonpartisan organization that is lead by a board of trustees composed of "leading Democrats, Republicans, and independents, business and labor leaders, former senior government official, scholars, writers and journalist". The Freedom House survey "Freedom in the World" is lead by Raymond Gastil, whereby the Freedom House index is sometimes also called the Gastil index. The Freedom House index is made up of two separate indexes: political rights and civil liberties, which are both rated on a 1 to 7 scale where 1 is the most free and 7 the least free. The ratings for each index are given by a group of about 30 analysts, writers and

[8] This said with the reminder that Gwartney and Lawson (2004) is published by the Fraser Institute, it still states that "the authors of this book have worked independently and opinions expressed by them are, therefore, their own, and do not necessarily reflect the opinions of the members of the trustees of The Fraser Institute."

[9] See http://www.fraserinstitute.ca/economicfreedom/index.asp?snav=ef

senior-level academic advisors. Information from a broad range of sources is gathered and evaluated. The ratings are then discussed and adjusted to ensure comparability and consistency. For each area, each analyst goes through a checklist of different characteristics that has to be evaluated.[10]

The political rights considered are briefly: The electoral process, political pluralism and participation, and the functioning of government. Some examples of questions in this area could be: Is the head of state and the legislate branch elected through free and fair elections? Do people have the right to organize? Is there a possibility for the opposition to gain power? Are the people free from domination by the military or other group(s)? Do minority groups experience reasonable self-government?

The civil liberties considered are: freedom of expression and belief, association and organizational rights; rule of law and human rights, personal autonomy and economic rights, including the strength of property rights and acknowledging the equality of opportunity; freedom from exploitation and dependency from landlords, employers, union leaders, bureaucrats or other types of obstacles to share from legitimate economic gains.

An advantage of the Freedom House index is that the country ratings are supposed to be based on real world situations caused by state and nongovernmental factors, and not on the governments' intentions or legislation. The index therefore tries to cover the rights and freedoms actually experienced by individuals in each country or territory and are not a rating of the government per se. Therefore I argue that the Freedom House index is close to the definition of institutions as emphasized by North (1996).

A disadvantage of the Freedom House index is first of all that it covers so many different aspects of freedom, and therefore be hard to interpret and disentangle the cause of a change in the index. Another disadvantage is that the index is completely subjective which makes it hard to evaluate, as well as it give less flexibility in constructing your own freedom measure based on the data provided, as can for example be done with the ICRG and the Fraser EFW datasets.

[10] For more info see: www.freedomhouse.org

3.3. Classification of Institutional Measures

In this section the four institutional measures are classified according to section 3.1 into: Type, Provider, and Specialization. The Classification is presented in Table 1. Since the institutional measures under examination in this paper are some of the most popular measures used in the empirical economics literature, these classifications could also give a representative picture of institutional measures at large.

From Table 1 we can see that all of the four institutional measures have some sort of subjective part, which is most often formed by the personal views of a group of experts which then form a sort of "consensus". This indexing creates a problem; how can we trust the objectivity of these consensus measures and how can we trust that they are reasonable? It is therefore informative to look at who is providing the measure and for what.

A business company that constructs a risk assessment that is to be used by investors seems often as a more reliable source than for example an organization that constructs their measure in order to justify their political beliefs. Institutional measures provided by organizations can therefore be hard to evaluate because there is always a risk that the measure is constructed to justify a specific perspective or viewpoint. From Table 1 it is only Expropriation Risk which is fully provided by a business company.

From Table 1 we can also see that the four institutional measure are often more general in nature. It is only Expropriation Risk that can be said to be specific. That the measures are more general is probably due to the somewhat diffuse definition of institutions which naturally leads to aggregation of a wide array of variables and dimensions. This generalization makes it hard to first of all evaluate the institutional measure itself; is there a specific component of the institutional measure that crucially determines its final score? Secondly, it is also hard to evaluate the institutional measures supposedly effect on other variables like for example income growth. This makes it hard to give policy advice.

4. Examining the Data

This section numerically compares the institutional measures in order to gain understanding of how similar the measures are to each other. To try to gain understanding, correlations as well as scatter plots will be examined between (1) the institutional measures, and (2) between the institutional measures and two measures of development: GDP per capita and the Human Development Index (HDI). For the relation between income and institutional measures, a method for identifying outliers has also been implemented.

4.1. Data and Methodology

Data for the Fraser EFW and the Freedom House index are both freely available from their respective webpage. Social Infrastructure in Hall and Jones (1999) and Expropriation Risk used in Acemoglu et al (2001), has had to be extracted from the papers themselves and corresponds to the period 1986-1995 and 1985-1995 respectively. In order to compare the measures, the Freedom House and the Fraser EFW index has been calculated to correspond to the period 1985-1995. For the development variables, GDP per capita and HDI, the year 1995 is used.[11]

It should also be clarified that to simplify the comparisons, the Freedom House index, which is originally on a scale from 1 to 7, where 7 means least free, has been reversed so that a high number instead means most free. In all the other measures, a high number corresponds to high institutional quality. Furthermore the institutional variables have all been normalized to be on a scale from 0 to 1, where a large number stands for high institutional quality. The normalization is calculated as $(V_i-V_{min})/(V_{max}-V_{min})$, where V_i , the original score, is subtracted from V_{min} , the minimum possible value of the index. This is then divided by the difference between V_{max}, the maximum possible value, and V_{min}. This normalization does in no way alter the correlation coefficients or distort the scatter plots.[12]

[11] See appendix for more information on variable definition and data sources

[12] The Social Infrastructure ranking is already on a 0-1 scale, and is therefore left untouched. The Fraser EFW ranking is between 0 and 10, as is also the Expropriation Risk ranking. The V_{min} and V_{max} for the Fraser EFW are therefore 0, and 10 respectively. For a more detailed description of the variables and data sources please see the appendix.

Since the institutional measures are more on an ordinal scale, the Spearman rank correlation will be used since it compares the ranks instead of the absolute values between the two data series. The Spearman rank correlation coefficient can also be used as a test statistic to test the hypothesis of "no association" between the two data series. From section 3 we already know that Social Infrastructure is related to Expropriation Risk and The Fraser EFW. This dependency between the institutional variables violates one of the assumptions of the Spearman rank correlation test. However, keeping this in mind, the correlation coefficients between these variables are still interesting to look at.

4.2. Results

The correlation coefficients are presented in Tables 2-7, where the correlation tables are divided between institutional measures versus institutional measures (Tables 2-4), and institutional measures versus development measures (Tables 5-7).

4.2.1. Institutions versus Institutions

The correlations between institutional measures are divided into three tables: Table 2 with pair wise correlations with as many observations as possible letting the sample size differ, Table 3 with the same sample size, and Table 4 with the same sample size but excluding Expropriation Risk due to its small sample size[13].

The perhaps first thing to notice in Tables 2, 3 and 4 is that the correlation coefficients change a lot when moving from sample to sample (from table to table). This exemplifies the notion that when dealing with cross country data, the results might be very sensitive to sample modifications. All in all the correlation coefficients range from 0.78 (between Social Infrastructure and Fraser EFW) to 0.36 (between Freedom House and Fraser EFW), with an average of about 0.6. All institutional measures are positively correlated and significantly associated according to Spearman's rank correlation test.

As noted above, Social Infrastructure has components which are also present in Expropriation Risk as well as the Fraser EFW. The correlation between these three measures is expected, but the correlation coefficient is not as high as one might think. Social Infrastructure has, depending on which country sample that is used, a correlation

[13] The small sample size is due to the fact that the data is retrieved from Acemoglu et al (2001).

coefficient of between 0.61 and 0.66. The correlation coefficient between Social Infrastructure and the Fraser EFW is between 0.66 and 0.77.

It is interesting to note that the Fraser EFW, Expropriation Risk and the Freedom House index, all are mostly correlated to Social Infrastructure. Fraser EFW, Expropriation Risk, and Social Infrastructure are all the least correlated to the Freedom House index. The Freedom House index is the least correlated to the Fraser EFW. This is in line with Hanke and Walters (1997) who compared the rankings between the Fraser EFW, the Freedom House index, as well as other similar measure from the Heritage Foundation, the World Economic Forum, and the International Institute for Management Development. Hanke and Walters (1997) concluded that the Freedom House index appears to have the least in common with the other rankings simply based on that the correlations between Freedom House and almost all other ranking is below 0.8, while the correlation coefficients between the other rankings is all above 0.8. A similar argument is made in Knack and Keefer (1995) where the "low" correlation between the Freedom House index and the alternative measures ICRG and BERI is interpreted as that the ICRG and the BERI are providing new additional information about the institutional environment.

In order to evaluate how similar the series are and to better single out differences, a visual inspection of the data might be helpful. Scatter plots between institutional measures is presented in Figures 2 and 3. These scatter plots are comparable to the pair wise correlations in Table 2. By looking at the scatter plots, all measures seem to have a pretty good fit with each other, but there are some disparities as well and it is here that the normalization to a 0 to 1 scale gives us guidance. For example, In Figure 2c, Singapore (SGP) and Malaysia (MYS) are given a ranking of about 0.8 by the Social Infrastructure index, but are "only" given a ranking of about 0.4 by the Freedom House index. This repeats itself in Figures 3b and 3c where Singapore is given a rating above 0.8 by the Expropriation Risk index as well as the Fraser EFW compared to the rating of about 0.4 by the Freedom House. This highlights some of the fundamental differences between the measures. While the Fraser EFW measures the extent of *economic* freedom, Freedom House has a mere emphasis on the *political and civic* freedom. It is here that the

user of the measures has to decide on which one is the most appropriate for his/hers needs.[14]

4.2.2. Institutions versus Development

Similar to the subsection above, the correlations between institutional measures and measures of development (GDP per capita and the Human Development Index) are divided into three tables: Table 5 with pair wise correlations letting the sample size differ, Table 6 with the same sample size, and Table 7 with the same sample size but excluding Expropriation Risk.

Overall, all institutional measures are highly and positively correlated to GDP per capita and the HDI. The institutional measures are even more correlated to GDP per capita and the HDI, than to any other institutional measure. Social Infrastructure is the institutional measure that is the most correlated with both GDP per capita and the HDI. In all but Table 6, Social Infrastructure has the highest correlation coefficients. The Freedom House index seems to be more correlated to the HDI than to GDP per capita. In Table 6, the Freedom House index is the variable most correlated to HDI. The Freedom House index is always more correlated to HDI than Expropriation Risk and the Fraser EFW are. This exemplifies again the notion that the Freedom House index is more politically oriented, and that the other measures have a more economic focus.

The Fraser EFW seems to be the institutional measure that is the least correlated with GDP per capita and HDI. Since the Fraser EFW is the least correlated with the Freedom House index, compared to the other two institutional measures, it is interesting that even the Freedom House index is more correlated to income and HDI, than the Fraser EFW is.

In Figures 4 and 5, the scatter plots between the institutional measures and log GDP per capita and HDI are presented. All graphs can be said to have a clear and distinct

[14] Singapore might score high economically, but politically and democratically it is another story. Singapore has wide powers in limiting citizens' rights and handicapping political opposition. For example, there is a law that limits anonymous donations to political parties and prohibits organizations from receiving foreign funding, making it more difficult for the opposition to raise funds. There is also a long history of where the ruling party files law suits against political opponents and critics. Since the judicial system has close ties to the ruling party, the outcome of these law suits has been biased and in favor of the ruling party. For more information: http://www.state.gov/g/drl/rls/hrrpt/2000/eap/index.cfm?docid=770, and http://web.amnesty.org/web/ar2001.nsf/webasacountries/SINGAPORE?OpenDocument

positive association between institutional quality and income as well as to the HDI. Income and the Fraser EFW (Figure 4d) seems to have an association resembling an S. Low economic freedom, as defined by the Fraser EFW, seems to be related to low levels of income. When then economic freedom increases at around 0.5, income per capita seems to take off, to later at higher degrees of economic freedom to settle down again. Another way to interpret Figure 4d is that there are actually three categories; one with low income and low economic freedom, one with high income and high economic freedom, and a third category for all the countries somewhere in between. The only countries that seems to deviate from this pattern are located in the upper left quadrant of Figure 4d. These countries are for example Poland (POL), Bulgaria (BGR) and Romania (ROM) where a lot has happened to economic freedom over the years 1985-95.

When comparing institutional rankings to income levels, it is tempting to do some regression analysis with outlier detection. Temple (1998) suggests a robust estimator especially suitable for cross country analysis and outlier detection. The method is called Least Trimmed Squares (LTS) and is argued by Rousseeuw and Leroy (1987) to be a highly robust estimator. LTS can be described as a method of identifying the most coherent part of the sample, which is based on the subset (of the whole sample) whose least squares fit, has the smallest sum of squared residuals. Outliers may then be identified as those who lie far away from the robust fit.

The LTS method of identifying outliers is implemented in this paper. The countries that are selected as outliers are simply different in some respect, and are those that have the least in common with the general association between the institutional measure and income. Between income and Expropriation Risk (Figure 4a), India (IND), Gambia (GMB), and Tanzania (TZA) are selected as outlier. Between income and Social Infrastructure (Figure 4b) it is only Yemen (YEM) that is singled out. Between income and the Fraser EFW (Figure 4d) no countries are selected. Between income and the Freedom House index (Figure 4c) Saudi Arabia (SAU), Oman (OMN), Bahrain (BHR), Kuwait (KWT), United Arab Emirates (ARE), Singapore (SGP) (all in the upper left quadrant), and the Solomon islands (SLB)(lower right quadrant) that are selected as outlier. Most of these countries in Figure 4c are oil countries and can for natural reasons

have a low level of institutional quality but at the same time a high level of income. Oil countries are often dropped from cross country growth regressions.

5. Summary and Conclusion

The purpose of this paper is to deepen our understanding of institutional measures in general, by critically examining four of the most influential measures of institutional quality. The four measures examined are: Social Infrastructure from Hall and Jones (1999), Expropriation Risk used in Acemoglu et al (2001), the Fraser Institute measure Economic Freedom of the World, used by for example La Porta et al (2002), and the Freedom House index used in for example Barro and Sala-i-Martin (1995).

Expropriation Risk is constructed by the PRS group, which specializes in providing professional risk assessments for investors. However, the measure Expropriation Risk has not been provided by the PRS group since 1997 and is instead combined with another measure, Repudiation of Contracts, to form the new measure Contract Viability. Furthermore, this new measure is given less weight by the PRS group in their overall ICRG index. This leaves us with two concluding remarks: First of all, is Expropriation Risk still an important variable, or should focus instead be somewhere else? Secondly, if there still is a desire to measure expropriation, the variable Contract Viability should be a more up-to-date choice.

The measure Social Infrastructure is created by Hall and Jones (1999) by combining the ICRG data with a measure of openness from Sachs and Warner (1995). The Sachs and Warner openness index has been heavily criticized by foremost Harrison and Hanson (1999) and Rodriguez and Rodrik (2000) who demonstrate that the index is completely driven by two variables that have little to do with openness: State Monopoly of Exports (which in fact is a dummy for sub-Saharan Africa), and the Black Market Premium (which is a proxy for macroeconomic imbalance). Rodriguez and Rodrik (2000) further argue that the way the openness variable is constructed makes it become a “super-variable” which will be robust to almost anything. Since the Sachs and Warner openness measure is an important part of Social Infrastructure, the critic against the openness measure also concerns Social Infrastructure.

The Fraser Institute's Economic Freedom of the World measure seems to be constructed based primarily on political beliefs, where government intervention should be reduced and workers' rights should be kept at a minimum. The question is then if this is what we mean with economic freedom and institutional quality? The Fraser measure is an illustrative example of why it is important to ask who is providing the measure and for what.

The Freedom House index has a more political and democratic approach that is supposed to be based on how the institutional environment actually works and not how the institutions are intended to work. This makes the Freedom House index close to the definition of institutions emphasized by North (1996). However, due to the pure subjective nature of the Freedom House index it is difficult to evaluate. The measure is also very broad, which complicates policy advice.

Statistically, the four measures are in general highly correlated. Social Infrastructure is the measure that is the most correlated with the other intuitional measures as well as to GDP per capita and to the Human Development Index. The Freedom House index is the measure that has the least in common with the other three institutional measures, and is in line with previous findings by Hanke and Walters (1997), as well as Knack and Keefer (1995). The fact that the Freedom House index is different is not necessarily a bad thing. An interesting difference between the Freedom House index and the other three institutional measures is the ranking of Singapore. In the Freedom House index, Singapore is given a quite mediocre ranking, whilst in the other three measures Singapore is ranked in the very top.

Because of the difficulty in deciding on the appropriateness of institutional measures, applied empirical research should consider the use of several alternative institutional measures, as well as instrumenting for institutional quality, as is for example done in Acemoglu et al (2000).

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Appendix

Description of the variables:

The countries in the sample that either split up or merged during the 1985-1995 period where simply dropped from the analysis. The countries that were dropped for these reason were; former Yugoslavia (Croatia, Slovenia, Bosina and Herzegovina), former Czechoslovakia (Czech Republic and Slovakia), and Germany (East and West Germany).

Social Infrastructure, from Hall and Jones (1999). The sample with 127 countries is being used. The data represent the time period 1986-1995. The GADP is the average of the five components for the years 1986-95. The Sachs and Warner (1995) openness measure is the fraction of years open during 1950-94. The ranking is on a 0 to 1 scale, and has therefore not been normalized. See also text. The data is obtained via Charles I. Jones' website: http://emlab.berkeley.edu/users/chad/HallJones400.asc

Fraser Institute Economic Freedom of the World (Fraser EFW). The 2004 data, associated with Gwartney and Lawson (2004) has been used. The data is obtained via the webpage: http://www.freetheworld.com/release.html. For the time period 1985-95, data is only provided for the years 1985, 1990 and 1995. The averages of these values have been used in the analysis. Countries which only had values for 1995 were dropped. Those countries were; Estonia, Cyprus, Latvia, Lithuania, Russia, Ukraine (and Croatia, Czech rep, Slovakia, and Slovenia, which has already been dropped.). Original score is from 0 to 10, and has been normalized to a scale of 0 to 1, [(score-0)/(10-0)].

Freedom House index. Freedom House's rating of Political and Civic Rights. The dataset "Freedom in the World Country Ratings, 1972-73 to 2001-2002" has been used. Data obtained from www.freedomhouse.org. The Freedom ratings consist of two ratings; political rights and civil freedoms. To get the freedom rating that is used in this paper, the average of these two ratings has been calculated for every year. Then the average for the years 1985-1995 has been calculated, where the listing 1984-85 has been interpreted as the year 1985, etc. The Freedom House index criteria have changed slightly over the years, so it is not completely appropriate to take the average over the period 1985-95. But since these modifications are small, and the main purpose as well as meaning of the index is still the same, these changes should make a small impact on the overall performance of the measure. The rating is originally a value between 1 and 7 were 7 means least free. The rankings have been reversed by simply taking 8 minus the original score. Normalized to be on a scale of 0 to 1, [(reversed score-1)/(7-1)].

Expropriation Risk. Average protection against expropriation risk, 1985-95. Data from Acemoglu et al (2001). On a scale from 0 to 10, where a higher score means less risk. Average value for all years from 1985 to 1995. Organized in electronic form by the IRIS Center at University of Maryland. Original components supplied by the PRS group. Normalized [(score-0)/(10-0)].

Ln GDP per capita (constant prices 1995) PPP, for the year 1995. Source: World Development Indicators 2004.

HDI 1995. Human Development Index for the year 1995. Consists of life expectancy at birth, adult literacy rate, and GDP per capita (PPP US$). Source Human Development Report 2004 <http://hdr.undp.org/statistics/data/>

Code	Country name		
AGO	Angola	EGY	Egypt
ALB	Albania	ERI	Eritrea
ARE	United Arab Emirates	ESP	Spain
ARG	Argentina	EST	Estonia
ARM	Armenia	ETH	Ethiopia
ATG	Antigua Barbuda	FIN	Finland
AUS	Australia	FJI	Fiji
AUT	Austria	FRA	France
AZE	Azerbaijan	GAB	Gabon
BDI	Burundi	GBR	United Kingdom
BEL	Belgium	GEO	Georgia
BEN	Benin	GHA	Ghana
BFA	Burkina Faso	GIN	Guinea
BGD	Bangladesh	GMB	Gambia, The
BGR	Bulgaria	GNB	Guinea Bissau
BHR	Bahrain	GNQ	Equatorial Guinea
BHS	Bahamas	GRC	Greece
BLR	Belarus	GRD	Grenada
BLZ	Belize	GTM	Guatemala
BOL	Bolivia	GUY	Guyana
BRA	Brazil	HKG	Hong Kong, China
BRB	Barbados	HND	Honduras
BUR	Burma	HTI	Haiti
BWA	Botswana	HUN	Hungary
CAF	Central African Rep.	IDN	Indonesia
CAN	Canada	IND	India
CHE	Switzerland	IRL	Ireland
CHL	Chile	IRN	Iran
CHN	China	ISL	Iceland
CIV	Côte d'Ivoire	ISR	Israel
CMR	Cameroon	ITA	Italy
COG	Congo, Rep. Of	JAM	Jamaica
COL	Colombia	JOR	Jordan
COM	Comoros	JPN	Japan
CPV	Cape Verde	KAZ	Kazakhstan
CRI	Costa Rica	KEN	Kenya
CYP	Cyprus G	KGZ	Kyrgyz Rep
DJI	Djibouti	KHM	Cambodia
DMA	Dominica	KNA	St Kitts Nevis
DNK	Denmark	KOR	Korea S
DOM	Dominican Rep	KWT	Kuwait
DZA	Algeria	LAO	Laos
ECU	Ecuador	LBN	Lebanon

Code	Country name		
LCA	St Lucia	SLB	Solomon Islands
LKA	Sri Lanka	SLE	Sierra Leone
LSO	Lesotho	SLV	El Salvador
LTU	Lithuania	SOM	Somalia
LUX	Luxembourg	SUR	Suriname
LVA	Latvia	SWE	Sweden
MAR	Morocco	SWZ	Swaziland
MDA	Moldova	SYC	Seychelles
MDG	Madagascar	SYR	Syria
MEX	Mexico	TCD	Chad
MKD	Macedonia	TGO	Togo
MLI	Mali	THA	Thailand
MLT	Malta	TJK	Tajikistan
MNG	Mongolia	TKM	Turkmenistan
MOZ	Mozambique	TON	Tonga
MRT	Mauritania	TTO	Trinidad Tobago
MUS	Mauritius	TUN	Tunisia
MWI	Malawi	TUR	Turkey
MYS	Malaysia	TWN	Taiwan
NAM	Namibia	TZA	Tanzania
NER	Niger	UGA	Uganda
NGA	Nigeria	UKR	Ukraine
NIC	Nicaragua	URY	Uruguay
NLD	Netherlands	USA	United States
NOR	Norway	UZB	Uzbekistan
NPL	Nepal	VCT	St Vincent & Grenadines
NZL	New Zealand	VEN	Venezuela
OMN	Oman	VNM	Vietnam
PAK	Pakistan	VUT	Vanuatu
PAN	Panama	WSM	Samoa
PER	Peru	YEM	Yemen
PHL	Philippines	ZAF	SouthAfrica1
PNG	Papua New Guinea	ZAR	Congo, Dem. R.
POL	Poland	ZMB	Zambia
PRI	Puerto Rico	ZWE	Zimbabwe
PRT	Portugal		
PRY	Paraguay		
ROM	Romania		
RUS	Russia		
RWA	Rwanda		
SAU	Saudi Arabia		
SDN	Sudan		
SEN	Senegal		
SGP	Singapore		

Table 1:
Classification of Institutional Measures

	Type of measure		Provider of measure		Specialization of measure	
	Subjective	Objective	Business	Non-Business	General	Specific
Social Infrastructure	X	X		X	X	
Expropriation Risk	X		X			X
Fraser EFW	X	X		X	X	
Freedom House	X			X	X	

Table 2:
Pair Wise Correlations between Institutional Measures, Different n

Spearman Rank Correlations				
	Social. Inf.	Exp. Risk	Fraser EFW	Freedom House
Social Infrastructure	1 124			
Exp. Risk	0.6641** 61	1 64		
Fraser EFW	0.7843** 104	0.5814** 57	1 112	
Freedom House	0.7094** 121	0.5032** 63	0.6216** 111	1 188

Notes: First number is Spearman rank correlation coefficient; second number is number of countries.
** Significantly associated at the 1% significance level (Spearman's rank correlation test). Normalization of the values does not change the results in any way.

Table 3:
Correlations Between Institutional Measures, Same n

Spearman Rank Correlation				
	Social. Inf.	Exp. Risk	Fraser EFW	Freedom House
Social Infrastructure	1 55			
Expropriation Risk	0.6195** 55	1 55		
Fraser EFW	0.5734** 55	0.5479** 55	1 55	
Freedom House	0.5701** 55	0.4480** 55	0.3631** 55	1 55

Notes: see table 2.

Table 4:
Correlations between Institutional Measures, Same n, excluding Expropriation Risk

Spearman Rank Correlation			
	Social. Inf.	Fraser EFW	Freedom House
Social Infrastructure	1 103		
Fraser EFW	0.7785** 103	1 103	
Freedom House	0.7345** 103	0.6631** 103	1 103

Notes: see table 2.

Table 5:
Pair Wise Correlations, Different n
Correlation Coefficients between institutions and Income per capita and HDI

Spearman Rank Correlation Coefficients (different n)				
	Social Inf.	Exp. Risk	Fraser EFW	Freedom House
GDP per capita 1995	0.8068 117	0.7114 64	0.7590 110	0.7121 158
HDI 1995	0.8081 112	0.6970 60	0.7293 108	0.7514 140
Pearson Correlation Coefficients (different n)				
	Social Inf.	Exp. Risk	Fraser EFW	Freedom House
GDP per capita 1995	0.7971 117	0.7362 64	0.7423 110	0.7140 158
HDI 1995	0.7671 112	0.6984 60	0.6657 108	0.7230 140

Notes: First number Correlation Coefficient, Second number is number of countries. Normalization of the institutional measures does not change the results in any way.

Table 6:
Correlations, Same n
Correlation Coefficients between institutions and Income per capita and HDI

Spearman Rank Correlation Coefficients (same n)				
	Social Inf.	Exp. Risk	Fraser EFW	Freedom House
GDP per capita 1995	0.7056 55	0.7250 55	0.6030 55	0.6807 55
HDI 1995	0.7341 53	0.7108 53	0.6069 53	0.7387 53
Pearson Correlation Coefficients (same n)				
GDP per capita 1995	0.7226 55	0.7579 55	0.6764 55	0.7051 55
HDI 1995	0.7042 53	0.7216 53	0.6066 53	0.7415 53

Notes: see table 5.

Table 7:
Correlations, Same n, excluding Expropriation Risk
Correlation Coefficients between Institutions and Income per capita and HDI

Spearman Rank Correlation Coefficients (same n, excluding Expropriation Risk)			
	Social Inf.	Fraser EFW	Freedom House
GDP per capita 1995	0.8472 101	0.7455 101	0.7941 101
HDI 1995	0.8452 99	0.7317 99	0.8208 99
Pearson Correlation Coefficients (same n, excluding Expropriation Risk)			
	Social Inf.	Fraser EFW	Freedom House
GDP per capita 1995	0.8293 101	0.7394 101	0.7915 101
HDI 1995	0.7936 99	0.6794 99	0.7863 99

Notes: See table 5.

Table 8:
Descriptive Statistics

	# of obs	mean	Std.dev	Min	Max
Expropriation Risk (norm.)	64	0.6516	0.1469	0.35	1
Social Infrastructure	124	0.4726	0.2491	0.11	1
Fraser EFW (norm.)	112	0.5516	0.1224	0.31	0.87
Freedom House Index (reversed, and norm.)	188	0.5137	0.3239	0	1
ln GDP per capita 1995	161	8.2574	1.1110	6.10	10.40
HDI 1995	141	0.6722	0.1842	0.27	0.94

Note: norm. Stands for normalized, see text and data appendix. Social Infrastructure is already a value between 0 and 1, and has not been normalized.

Figure 1

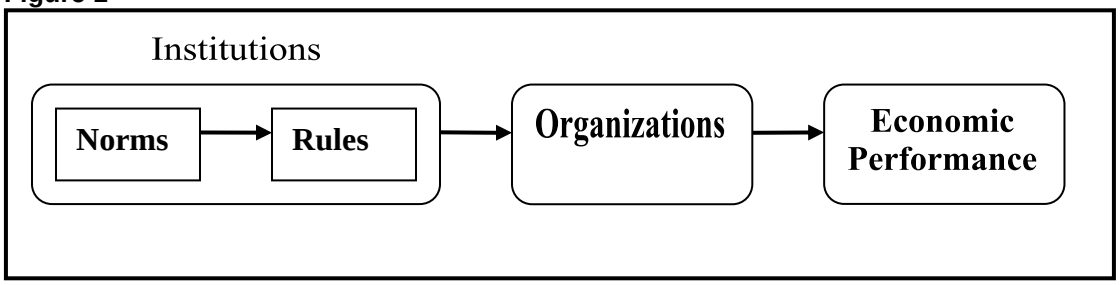


Figure 2a

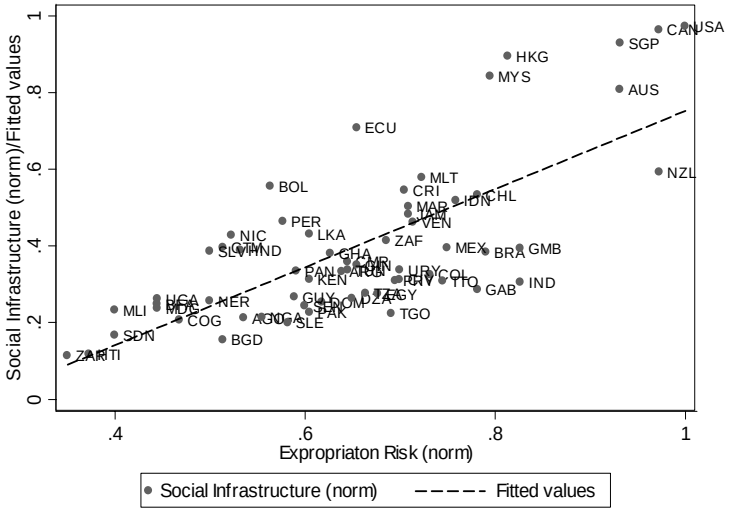


Figure 2b

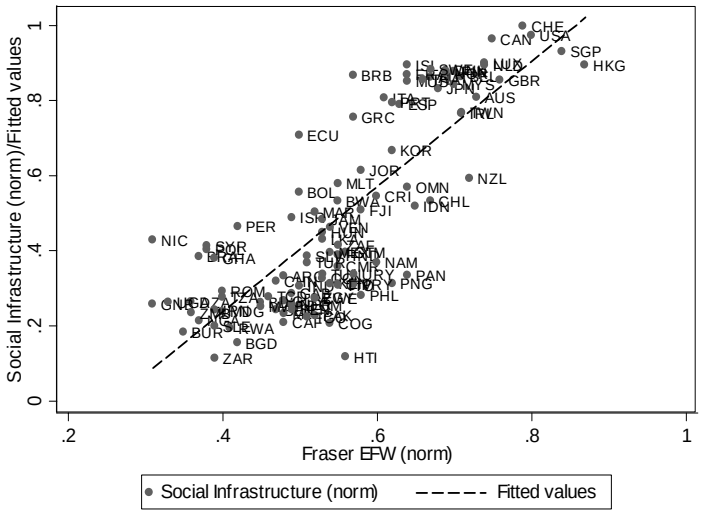


Figure 2c

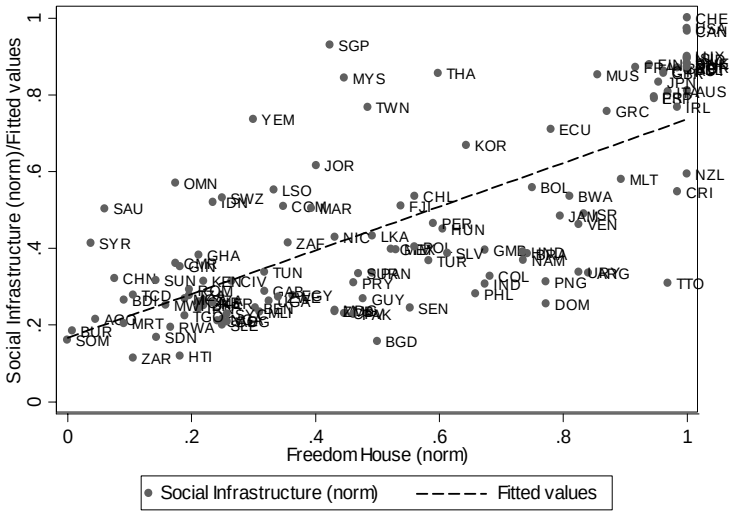


Figure 3a

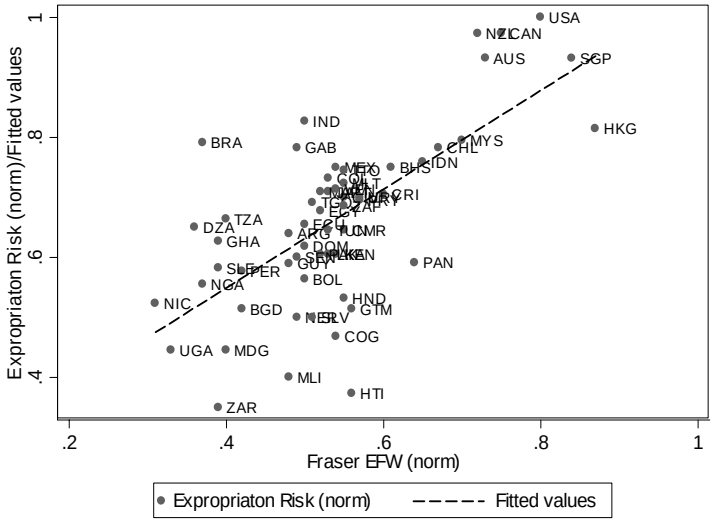
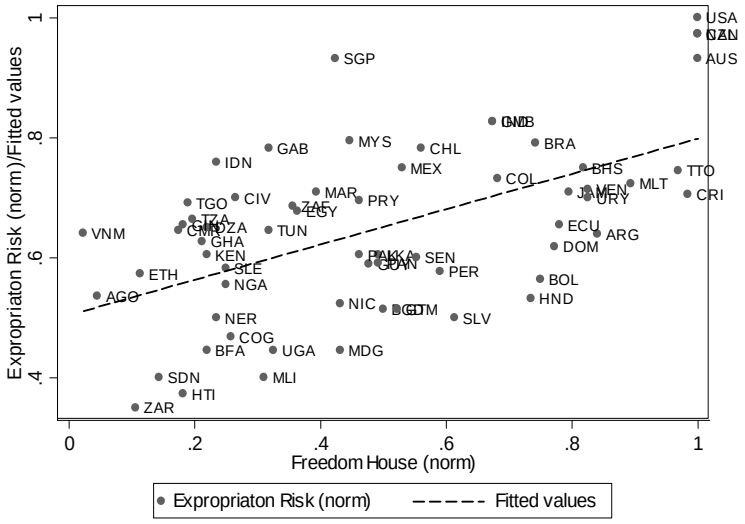


Figure 3b



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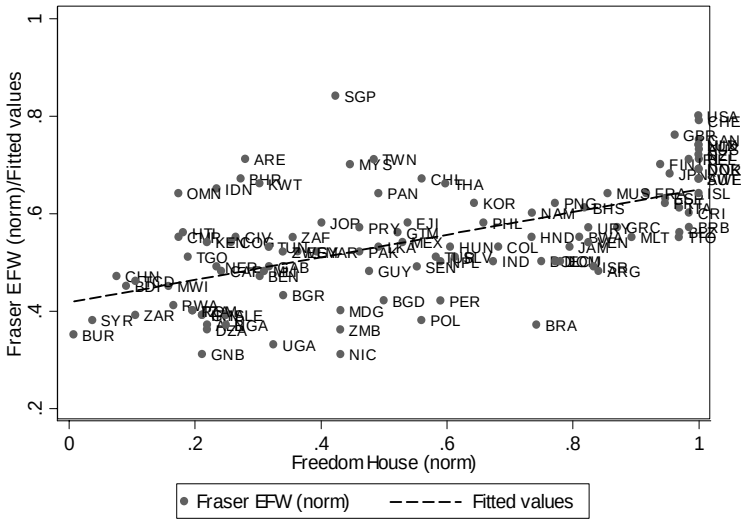

Figure 4a

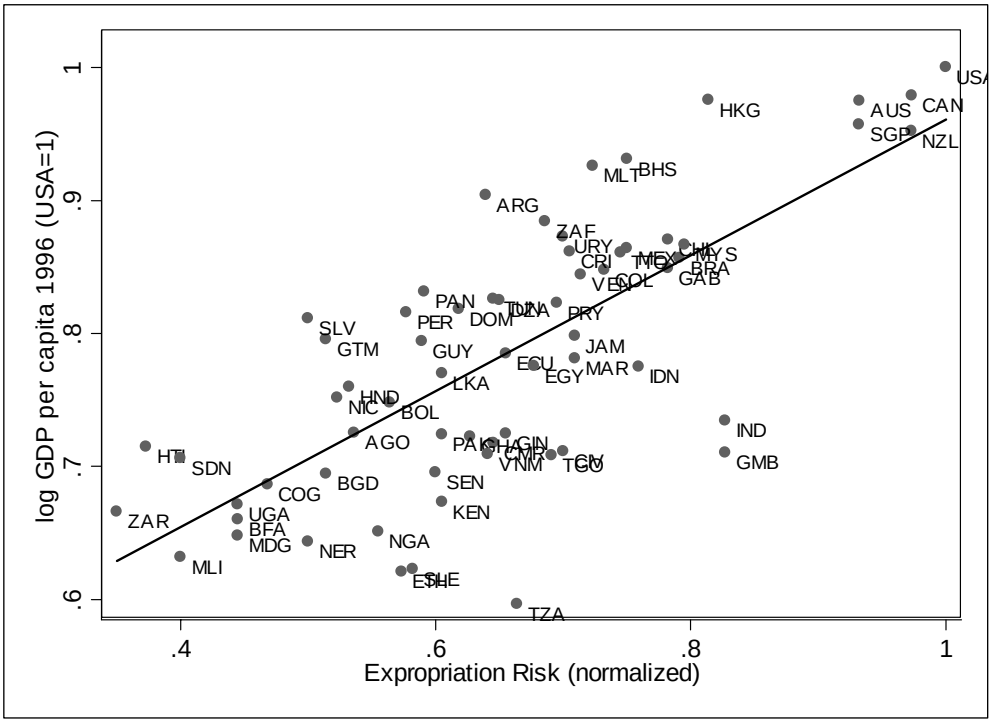

Figure 4b

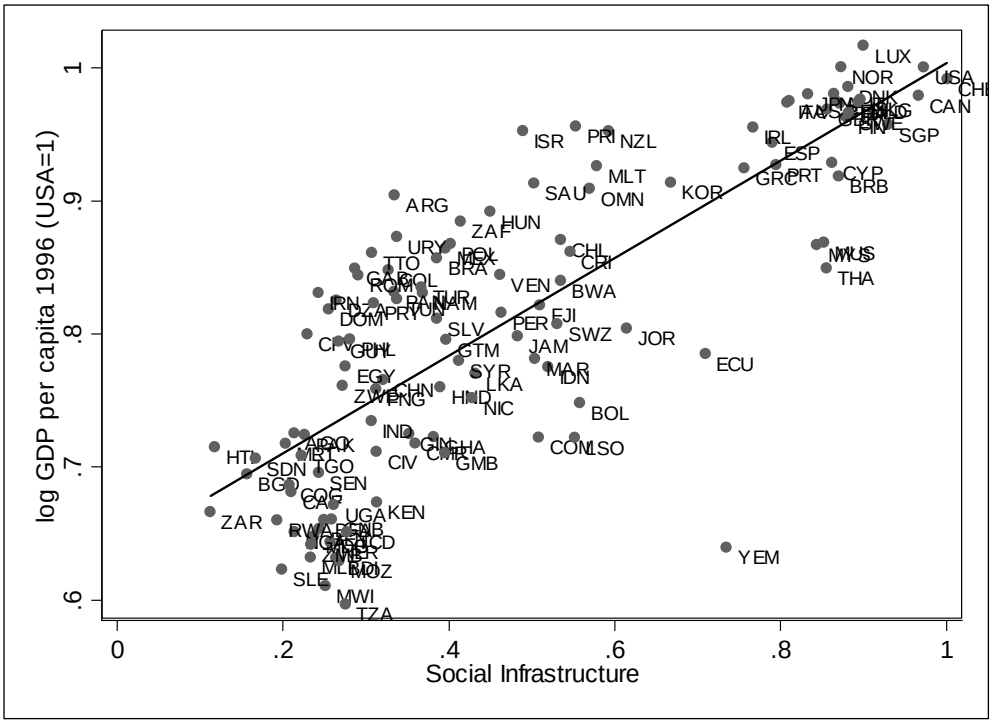

Figure 4c

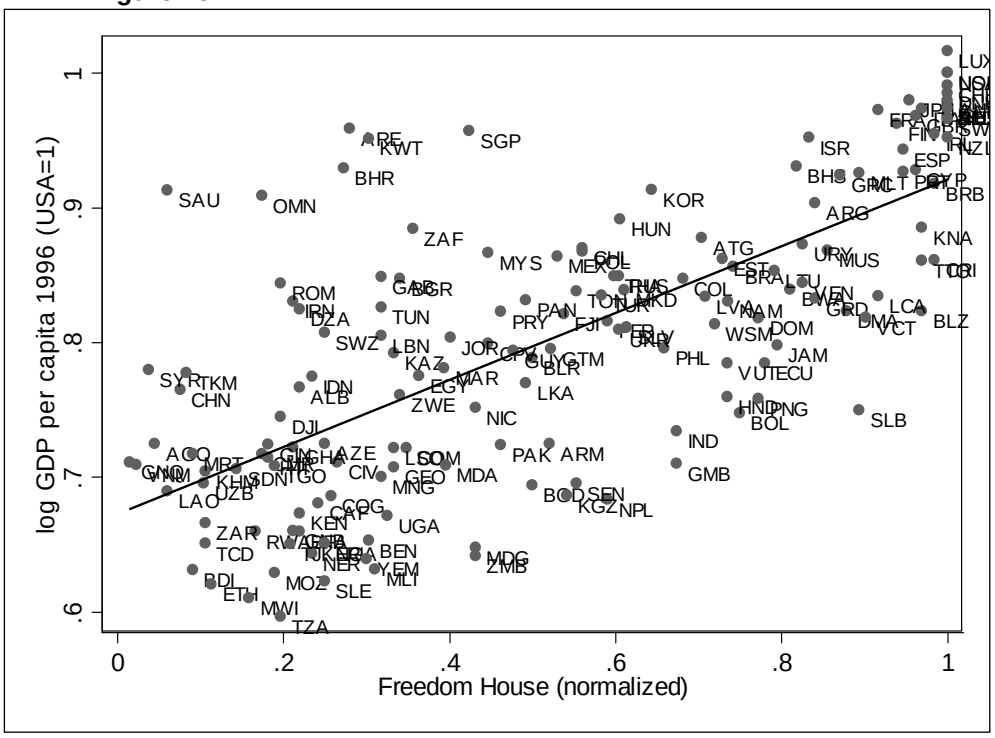

Figure 4d

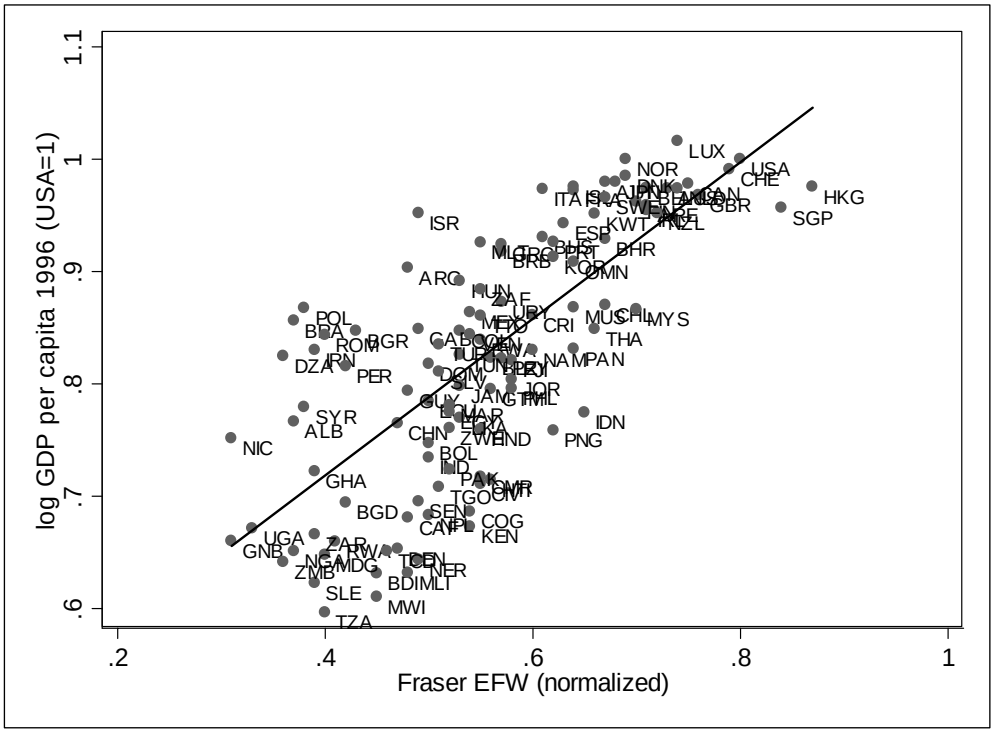

Figure 5a

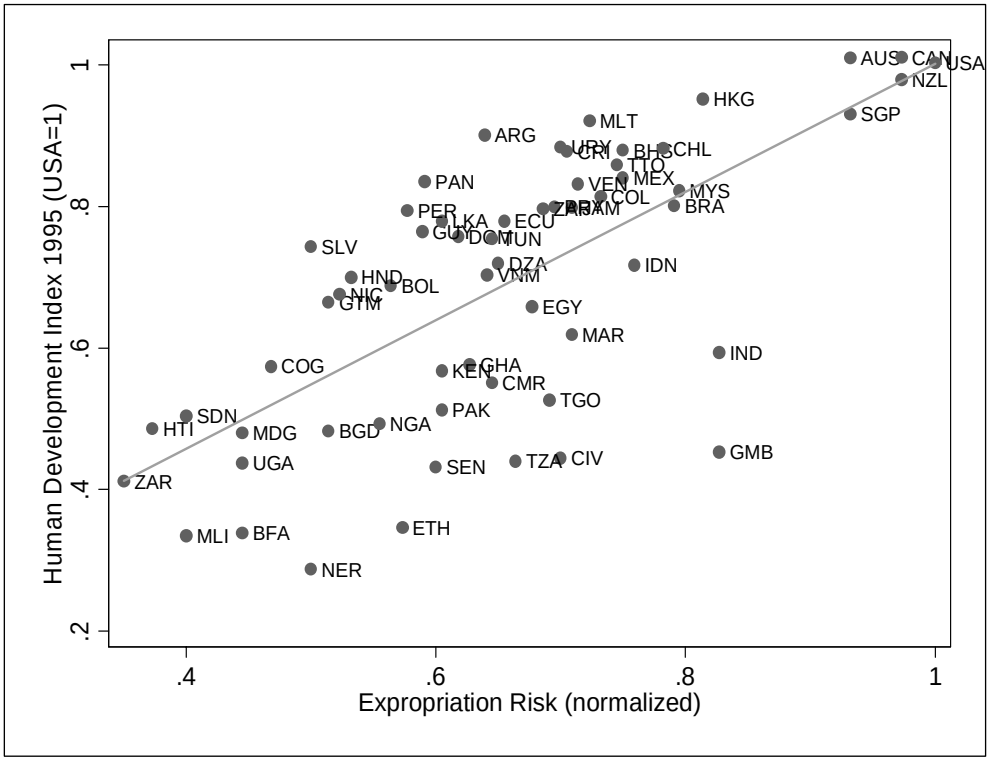

Figure 5b

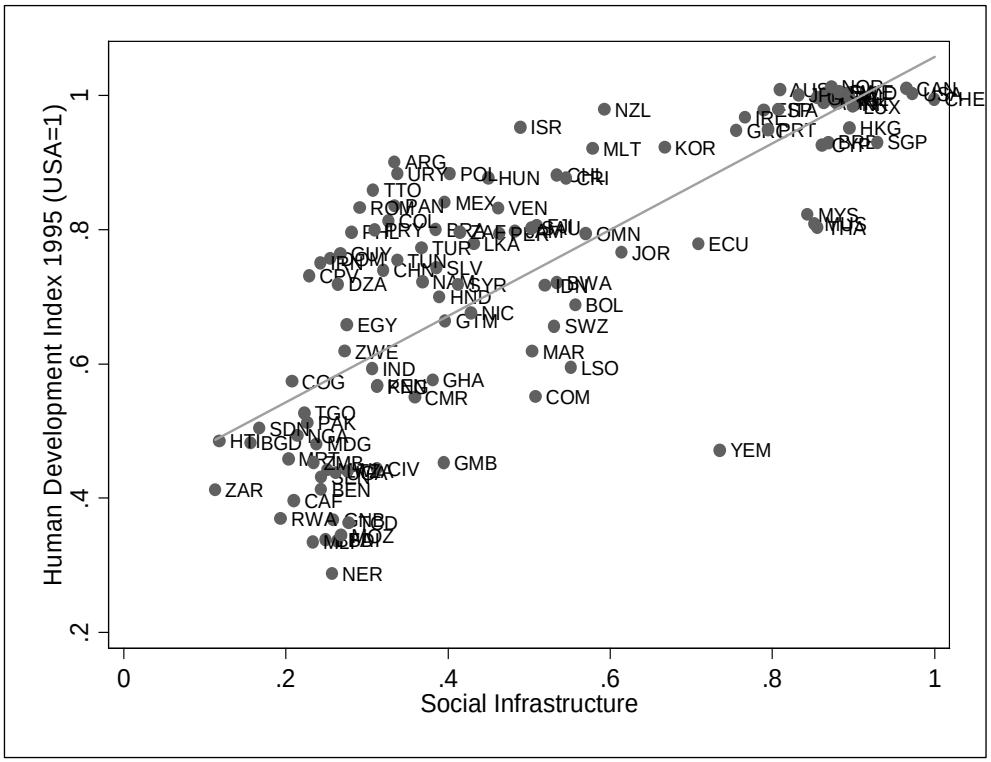

Figure 5c

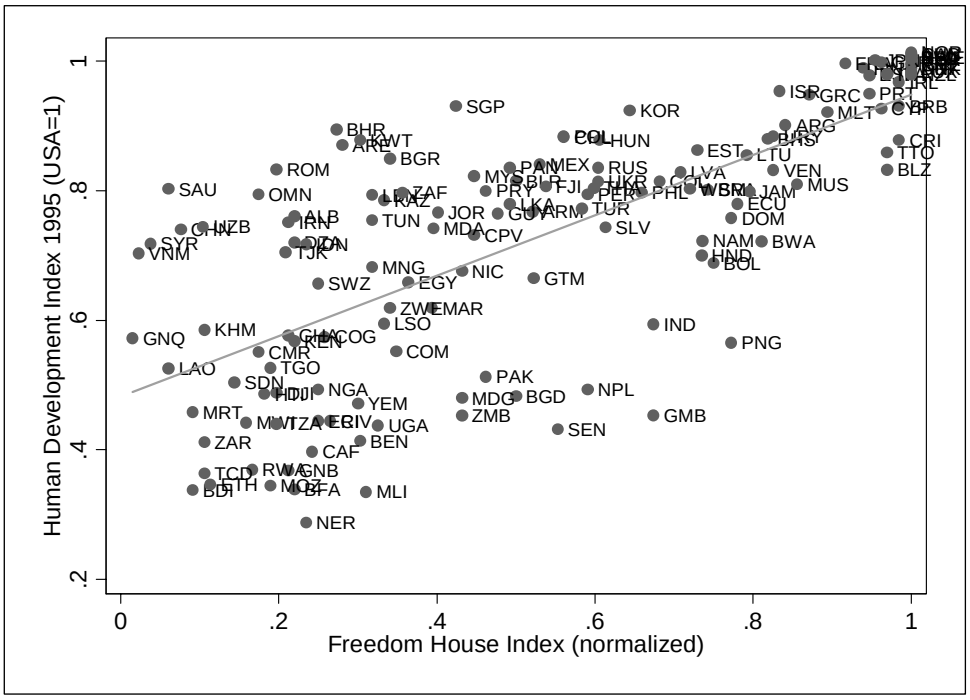

Figure 5d