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The Transition of Corruption

Institutions and dynamics

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Abstract: The paper analyzes the strong but complex relation between corruption and development. The corruption/honesty index is explained by three variables measuring aspects of development: Income, Polity and Fraser (for Economic Freedom). The last two indices represent the political and the economic system. Two problems arise: (i) Development is a common factor in all four variables, giving the variables strong confluence, so it is difficult to sort out the contribution of each explanatory variable. However, kernel regressions on the corruption/income scatter give a well-defined long-run transition path, which permits an identification of the specific contributions of institutions to corruption. (ii) The correlation of corruption to the first difference of the three development variables is negative. This gives a substantial lag in the corruption/income relation in the form of wide J-curves, but the main direction of causality is still from development to corruption. High income and modern institutions cause low corruption after some time. The corruption/development-relation is a fuzzy but strong long-run connection.

Keywords: Corruption; transition; institutions; fuzzy relations

Jel code: D73, K42, P48

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1. The complex corruption/development-relation

The literature on corruption has found that *development* is the strongest explanation of the cross-country levels of perceived corruption/honesty.[2] Sections 2 and 4 confirm that honesty goes together with high income and modern institutions. The available historical narrative provides the same story – a couple of centuries ago, when the present developed countries were poor, they were also quite corrupt.[3] Figure 1 reveals a 'perfect' long-run transition curve, much like the ones for agriculture, democracy, fertility and mortality.

While the long-run-relation is clear, it proves complex how it comes about in the shorter run. We all like clear, direct effects such as the relation of the price and quantity for a good on a market. However, the effect of development on corruption is of a different nature, which is explored by this paper. It works through other changes in society brought about by development. This gives the problem of *confluence*: corruption is explained by a set of highly correlated variables.[4] Income is a fine proxy for development, but it is not the full story. Two main indices of institutional development – the Fraser and the Polity indices – are shown to have similarly strong correlations to corruption. The corruption/development relation *is strong, but fuzzy*. This paper tries to untangle the confluence as regards the explanations of corruption.

In addition to the problem of confluence, there is a short-run problem in the form of a *short/long*-run contradiction. While the correlations between corruption and levels of the three development variables are positive, the correlation of corruption to the first differences of the three variables is negative. While development causes honesty to increase, it happens via *J-curves*, with a downswing that lasts a dozen years before the improvement comes to prevail. This tallies with the old observation that corruption is an '*embedded tradition*', which changes slowly. It causes the transition of corruption to happen later than most other transitions.

One of the controversies in the literature concerns the main causal direction between corruption and development. Many believe that a reduction in the social ill of corruption will cause development to increase. This is known as the *sand theory* as it sees corruption as sand in the machine of development. The *transition theory* claims that development causes corruption to fall, as suggested by the late transition of corruption. Several causality tests are reported; they agree that causality is from development to corruption.

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[2] The income effect on the cross-country pattern of corruption is known since Treisman (2000) and Paldam (2002), who worked with 330 observations (until 1999). Today the data has increased tenfold, and the income effect is much stronger. The meta-study by Ugur (2016) confirms that the result generalizes.
[3] The 20 authors of Kroeze *et al.* (2018) survey the historical evidence in a set of references that runs to 42 pages.
[4] A set of variables is confluent when a factor analysis shows that it has one strong common factor, see section 4.1. With such variables, the explanation of one by some of the others becomes strong and fuzzy.

Section 2 presents the data and an estimate of the transition curve by kernel regression, while section 3 considers the relevant theory. Section 4 reports correlations showing the confluence of the level variables and the short/long-run contradiction. It also presents the *D*-variable for corruption net of the transition. Thus, it measures relative corruption. Section 5 reports causality tests, showing that income is causal to corruption. Section 6 tries to untangle the effects of income and institutions using standard panel regressions and the *D*-variable, while section 7 concludes. Appendix 1 lists variables and terms. Appendix 2 compares the corruption index to the alternative indices from Gutmann *et al*. (2020).

2. Data and the transition curve

Section 2.1 deals with the data (see also Appendix 1), while section 2.2 displays the corruption/-income scatter and the transition curve. Section 2.3 shows the robustness of the curve.

2.1 The data: four level variables, T, y, F, P, and three first differences, g, dF, dP

The four level variables are: *Corruption* ***T***, is *Transparency* International's corruption perception index, which starts in 1995. It is scaled to be low for corruption and high for honesty. *Income* ***y*** = ln(*gdp*), where *gdp* is GDP per capita. Income is on a logarithmic scale, as *gdp*-data are roughly log-linear. The *economic system* variable ***F***, is the Fraser index of economic freedom. Annual data for Fraser starts in 2000. The *political system* ***P***, is the Polity-index (Polity2). Section 6.2 shows that both system variables have a long-run transition.

The first difference variables are: The *growth* ***g*** of the *gdp*. The two system first differences ***dF*** and ***dP***, are the average numerical change in two indices for as many observations as are available between 1995 and 2016. Section 6.1 further describes *F*, *P*, *dF* and *dP*.

The data are divided into two samples: The ***Main*** sample and the ***OPEC*** sample, which are the observations for all countries that are or have been members of OPEC (Organization of the Petroleum Exporting Countries). Table 1 gives some statistics for the *T*-index.

Table 1. Descriptive data for the corruption index, *T*

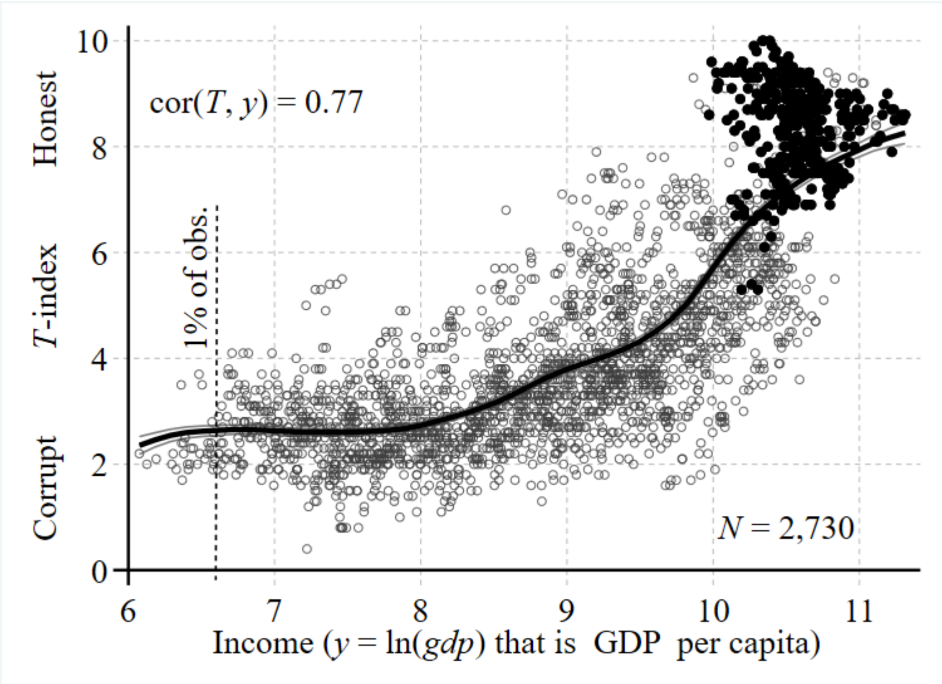
	Main	*OPEC*	All	Average	Std	Min	Max
All 1995-2016	2,730	247	2,977	4.4	2.2	10.0	0.4
Country averages	173	15	188	4.1	2.0	9.4	1.0

Note: The *T*-data are the sample that can be combined with an income observation from the Maddison project database. The data are for 188 countries and 22 years. The (188, 22)-panel has 4,136 cells, so 28% of the cells are empty. Note that some calculations use the unified sample of all N = 2,730, while others use the panel-structure.

2.2 The corruption/income scatter and the long-run transition curve

Figure 1 reports the (T, y)-scatter for the Main sample. To analyze the long run, the scatter is summarized by the kernel regression, $T = K^y(y, 0.3)$. The estimation starts by unifying the panel and sorting by income, and then a smoothed moving average with a constant bandwidth is estimated using the kernel formula. The advantage of this technique is that the sorting scrambles the panel structure, so that residual covariance and the effect of other explanatory variables than y are suppressed. Hence, it estimates the underlying long-run path. The narrow confidence intervals show that the curve is well determined. The graph suggests two stylized facts:

Figure 1. Corruption-income scatter for *Main* sample, with kernel regression $T = K^T(y, 0.3)$



Note: $K^T(y, 0.3)$ is the Epanechnikov kernel with bandwidth, $bw = 0.3$, and 95% confidence intervals. They are very narrow, so they are hard to see over most of the range. The black circles are the Old West: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, New Zealand, Norway, Sweden, Switzerland, UK and USA. The vertical dotted line shows that the leftmost part of the curve is supported by 1% of the observations only.

(i) The kernel-curve looks as a transition curve should: It diverges from a corruption level at about $(T, y) \approx (2.5, 6.5)$ in poor countries, and ends at about $(T, y) \approx (8.5, 11)$ in wealthy countries.[5] The average slope is 1.33.

(ii) The convergence of the transition is not complete, but it is clearly underway, and as

[5] The income values 8 and 9.5 are for *gdp*'s in 2016 at \$ 3,000 (Kenya), and \$ 13,500 (Brazil), respectively.

it has an upper bound at 10, it is likely to become horizontal a bit before that. The black circles are for the oldest developed countries, see note to figure. They have a corruption level that approaches 9. These countries have been wealthy for long and have therefore adjusted to the wealth. This suggests that the convergence will be to about 9.

2.3 *The robustness of the transition curve from Figure 1*

The stylized facts (i) and (ii) will be used below, so it is important that they are robust. Figure 2 reports additional kernel curves analyzing the robustness of the transition path. The reaction of the kernel to the bandwidth, *bw*, is shown by Figure 2a. As usual, the kernel is a bit wobbly for small *bw*s and becomes flatter for large *bw*s, but the basic form is robust. Figure 2b reports that the curve is stable over time. Figure 2c shows that the transition curve has the same form in the *Main* sample and the *OPEC* countries. As the *OPEC* countries are relatively wealthy at each level of development, the *K*-curve shifts to the right for these countries.

Figure 2. Analyzing the robustness of the kernel-curve, $K^T(y, bw)$, from Figure 1

Figure 2a. Six bandwidths, *bw*

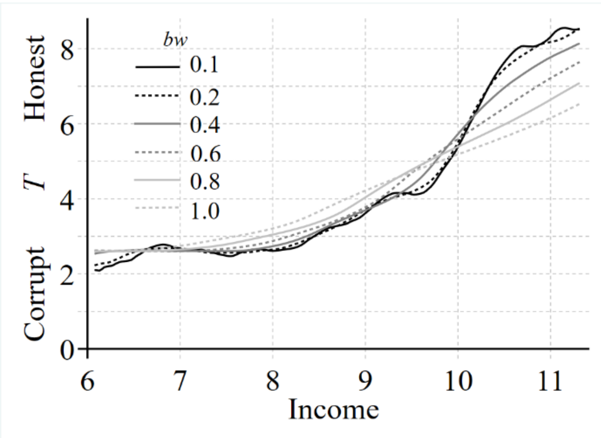


Figure 2b. Five periods

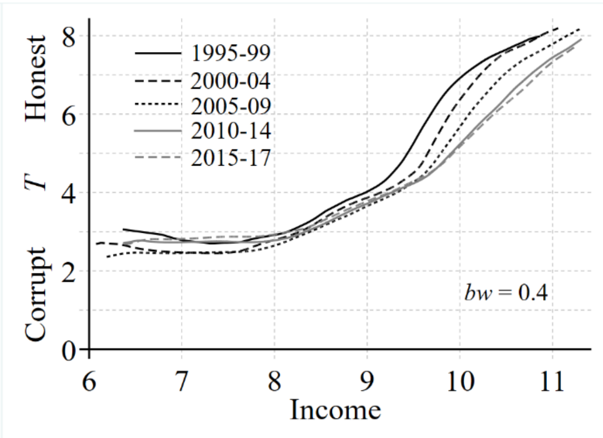


Figure 2c. *Main* vs *OPEC* sample

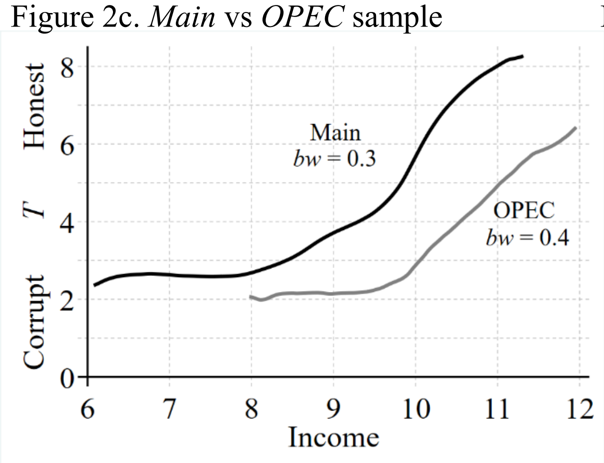


Figure 2d. The transition kernel and its reverse

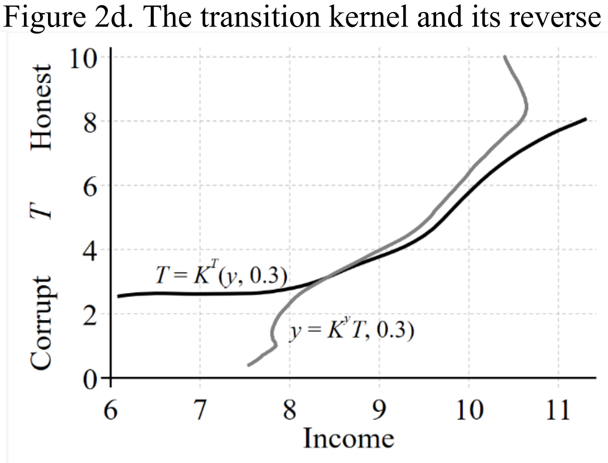


Figure 2d is more complex, as it reports an informal causality test. It compares the transition curve assuming causality from y to T, with the kernel assuming the reverse causality. Due to sorting and averaging, the two reverse kernels often look rather different (see Paldam 2020). This is also the case at present. The $T = K^T(y, 0.3)$-kernel looks as it should according to transition theory, but the $y = K^y(T, 0.3)$-kernel is more difficult to explain.

3. How does theory explain the corruption/income-relation?

Scattered corruption data started in the 1980s, and the NGO Transparency International compiled them to an aggregate index in the mid-1990s. The old literature before that was theory based on anecdotal evidence.[6] After data became available, a new literature emerged. Two large books survey these literatures and republish the main papers: Heidenheimer *et al.* (1989) for the old literature, and Dutta and Aidt (2016) for the new.

3.1 Definition and measurement precision

The first question in the old literature is how to delimit corruption from other types of fraud and rent seeking. A number of definitions have been proposed. The paper uses Transparency's definition: *Corruption is the abuse of entrusted power for private gain*. This definition implies a principal agent framework, with an agent who deals with a third party. Corruption occurs when the agent colludes with the third party to defraud the principal. The longest chains of agents and sub-agents exist in the public sector. Hence, it is particularly prone to corruption.

The first question in the new literature is the quality of the measurement: Transparency's T-index aggregates a number of primary indices of perceptions of corruption by a calibration method developed by Johann Graf Lambsdorff; see the appendix of his book from 2007.[7] Aidt (2003) gives a survey of the early measurement discussion; see also Appendix 2. The compilation method for the T-index has changed over time, notably in 2012; see Gründler and Potrafke (2019). However, when the annual cross-country correlations, cor(y, T) and cor(g, T), are calculated, they have no kink in 2012; see Paldam (2020). The operational solution is to note that the index has a measurement error of almost one T-point. The T-index contains a

[6] The old literature suffered from politeness. Though it was widely known, it was considered impolite to mention that the level of corruption is higher in poor countries. Consequently, most papers in Heidenheimer dealt with the USA, and the 1,776 pages of volume 1 of the Handbook of Development (Chenery and Srinivasan 1988-89) did not mention corruption. This changed after data appeared, as seen already from the title of Dutta and Aidt (2016).
[7] The calibration means that the 38 countries covered all years have virtually the same average score throughout, but the average for all countries falls due to the gradual inclusion of more low- and middle-income countries.

complex process of residual correlation that is partly caused by measurement, which has changed over time. However, the conclusions are based on data sets with large *N*s, where the measurement error should be divided by the square root of *N*.

3.2 The concept of a transition and the demand and supply side of development

It is a well-known observation that economic history has found two basic steady states: The traditional and the modern. Socio-economic variables have stable, but very different levels, in the two steady states. A move from one steady state to another is termed a transition. It consists of a divergence from the traditional steady state and a convergence to the modern steady state. In-between we expect to find a neat path.[8]

Transitions can be studied empirically in two dimensions, long time-series or wide cross-country samples, with countries across the full income range. For corruption, only cross-country data are available. They show a fine transition curve as depicted on Figure 1, with narrow confidence intervals. The qualitative historical data seems to support that picture. It can be explained from both the demand and the supply side:

The demand theory sees honesty as an intangible good with a positive income elasticity. It speaks for the theory that it can be extended to a whole family of intangibles, such as democracy, generalized trust and various cultural goods. They are 'nice' to have, but not really necessary, so the demand for these goods increases when income rises. Poor countries are weak on honesty and democracy, and have few art museums. The consumption of other intangibles, such as religion, decreases when income rises. Thus, intangibles may have both positive and negative income elasticities. Such goods are imprecisely measured, and they are not sold on a market, so their prices are difficult to impute. Thus, the parallel to goods is a bit of a construct – it is, at best, a rather fuzzy relation. In this theory the causality is: $y \Rightarrow T$.

The supply theory sees corruption as an *inefficiency* in all transactions. It has to be hidden from the principal, and this takes time and effort. In poor countries, many deals involve a lengthy process of haggling, where some part may be a secret part of the deal. Modern mass production squeezes out such inefficiencies. Corruption may change to be a fixed commission or a tip that appears on invoices. Hence, it ceases to be corruption. This is, once again, a rather fuzzy relation, which might be interpreted as a causal relation: $y \Rightarrow T$.

Both theories see corruption as a social ill that vanishes with development.

[8] Paldam (2020) discusses transition theory and shows the transition curves for nine socio-economic datasets, including the Polity and the Fraser data.

3.3 The causality controversy and the sand vs grease parables

However, the transaction theory may be interpreted in a different way. When corruption is an extra cost that delays development, this means that if corruption is reduced, this will increase development. This is also known as the *sand theory*, as it sees corruption as sand in the machine of development. If the amount of sand is reduced, the machine will surely run better.

Thus, the sand theory provides a double argument to fight corruption. It is not only a social ill in itself, but also *sand* in the machine of development. Many authors, notably Lambsdorff (2007), stress this theory and provide evidence. This theory predicts that the correlation of T and growth is positive. This is contrary to the evidence found in Tables 2 and 3 below.

Given the evidence, it is possible that corruption works as *grease* in the machine, increasing efficiency. Thus, in a growth perspective corruption is either sand or grease in the machine.[9] In other words, a briber may see the bribe as a cost or as a cost-saving device. Especially as regards public regulations, it is easy to come up with examples supporting either view. The examples hinge upon externalities:

Many regulations improve national welfare, so corruption reduces the improvement. Examples are compulsory inoculation programs to eradicate epidemic diseases,[10] or regulations reducing air pollution, etc. Even if corruption allows both agents in the transaction a short-run welfare improvement by circumventing the regulation, this has negative externalities. Other regulations harm national welfare, so corruption limits the harm: It is easy to mention regulations that mainly serve to produce rents to politically influential groups. This, e.g., applies to most tariffs. In many less-developed countries, it is also a problem that the time and effort needed to obtain legal property rights to a business are far too large; see de Soto (2000).

While such grease-cases exist, they often have dynamic side effects that may change the conclusion: Perhaps the risk of corruption has made it necessary to have several layers of expensive controls that slow down the administration, so it is corruption that turns corruption into grease! A further aspect of the story is that the regulators may slow down administrative processes precisely to extract bribes. To understand such cases needs a complex model, where the solution is fragile depending upon the details of the case modeled.

Several researchers have tried to estimate reduced form models, with both grease terms and sand terms. Normally they both become significant, but they are hard to sort out; see Méon and Sekkat (2005) and Méon and Weil (2010) for somewhat different results.

[9] The sand theory is, as mentioned, much more popular. The grease theory goes back to Leff (1964).

[10] The author once visited a vaccination clinic in the 'African bush' that gave a choice of either a vaccination and the WHO-stamp in your vaccination booklet, or just the stamp. The latter was cheaper and less painful.

As the negative effect of growth on corruption is small, it is possible that it can be turned to become positive by effective policies to combat corruption, as discussed in many papers.[11]

3.4 The internal dynamics of corruption

Many papers, starting perhaps with Andvig and Moene (1990), argue that corruption is dynamic: Corrupt countries tend to become more so, and honest countries become more so as well. Thus, corruption has a high and a low equilibrium. Paldam (2002) gives an overview of some mechanisms having this 'seesaw' dynamics:

(i) It is impossible to punish everybody if all are corrupt, but if few are corrupt, they can be punished. (ii) The corrupt needs to announce his business, and it is typically done by conspicuous consumption – driving a Mercedes Benz is the classical method in poor countries. With low corruption, such advertisement announces a criminal. (iii) Jobs have different potential for corruption, and the jobs with the highest potential see wages competed down, so that the honest seek other jobs. Thus, the corrupt and the honest sort themselves out in jobs by high and low potential for corruption – this increases corruption.

This suggests that corruption, *T*, is stuck at rather low values in most countries, as seen below, but once it starts to fall, the rise in *T* is quite large. This helps explaining why the transition of corruption happens late in the process of development; see section 6.

3.5 Corruption and institutions

There are many institutions. The discussion concentrates on the political and economic systems, as measured by the level variables *F* and *P* and their first differences *dF* and *dP*.

Corruption and political institutions: Apart from the confluence, it is likely that democracy and honesty reinforce each other. When civil servants are honest, people are more likely to trust elections, and hence the elected politicians. Thus, the correlation of the *T*-series and the Polity index, *P*, is likely to be more than spurious. The *D*-index (defined in section 4.1) is corruption net of the transition, so it should eliminate spuriousness.

Corruption and economic institutions: People have different economic ideologies. The Fraser index was announced as a measure of the freedom to run a private business. Thus, apart from the confluence, *F* is linked to corruption in another way: Corruption often occurs to evade public regulations, and high values of the Fraser index indicate that few such restrictions exist. Once again, the *D*-index should reduce spuriousness in the relation.

[11] In June 2020 Google Scholar gave 124,000 hits to 'anti-corruption policies'.

The two measures of institutional change are measures of instability/uncertainty. Parallel to poverty, uncertainty is a hardship that is likely to increase corruption. Unfortunately, also instability has the problem of confluence; see Paldam (2020). The empirics of section 6 strive to sort out the effect of development as proxied by income from other effects analyzed.

4 Main facts about the corruption/development-relation

Section 4.1 shows the strong confluence of the level variables corruption, income and institutions, and introduces the *D*-index measuring relative corruption. Section 4.2 shows the negative relation between corruption and the first difference variables. Section 4.3 shows that the corruption moves slowly. Section 4.4 reports a set of panel-regressions,

4.1 The strong confluence of the level variables, and the D-index of relative corruption

Columns (1), (2) and (3) in Tables 2 and 3 show correlations between Corruption *T* and the three level variables: income *y*, Polity *P* and Fraser *F*. In Table 2, the left-hand panel is for the *Main* sample, and the right-hand panel is for the *OPEC* sample. The correlations to the level variables have the same numerical size, but the correlations to *P* have the reverse signs.[12]

Table 2. The correlation between level variables, for all observations

		(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
		Main sample, avr. *N* = 2,730				*OPEC* sample, avr. *N* = 247			
		Income	*F*-index	*P*-index	Growth	Income	*F*-index	*P*-index	Growth
(1)	*T*, Corruption	**0.774**	**0.726**	**0.450**	**−0.092**	**0.790**	**0.740**	**-0.488**	−0.046
(2)	*y*, income	**-**	**0.738**	**0.441**	0.022	**-**	**0.629**	**-0.542**	0.026
(3)	*F*, Fraser		**-**	**0.461**	0.024		**-**	**-0.289**	−0.016
(4)	*P*, Polity			-	−0.031			**-**	−0.016

Note: Estimates are bolded if they are significantly different from zero at the 5% level. Each correlation is for all overlapping observations available between 1995 and 2016. This makes *N* vary by 15%. A consistent sample is smaller, and gives virtually the same results. Table 3 uses a consistent sample.

The correlations of corruption to the other level variables (*y*, *F* and *P*) are very similar in Tables 2 and 3. The three correlations add to about two, so the three 'explanations' of the *T*-index must to a large extent explain the same twice.

[12] The reverse sign story deals with missing Democratic Transition in the OPEC countries; see Paldam 2020.

Table 3. Correlations of the corruption variables and institutions for country averages

	(1)	(2)	(3)	(4)	(5)	(6)
Correlations		*Level variables*			*First difference variables*	
N = 144	y, income	F, Fraser	P, Polity	g, growth	dF, to F	dP, to P
T, corruption	**0.75**	**0.74**	**0.41**	–0.10	**–0.48**	**–0.48**
D, net of transition	–0.05	**0.39**	**0.40**	–0.03	**–0.25**	**–0.17**

Note: See Table 2. Data are *Main* sample for 2000-16. dF and dP are the average numerical change.

The factor analysis of Table 4 confirms the strong confluence. The four level variables contain one, and only one, strong common factor that is interpreted as development. It follows that multiple regressions between these variables suffer greatly from multicollinearity.

Table 4. A factor analysis of the four annual level variables T, y, F and P

Importance of factors			Factor loadings		
Factor	Eigenvalue	Cumulative	Variable	Factor1	Factor2
Factor1	2.416	1.098	T, corruption	0.856	–0.048
Factor2	0.018	1.106	y, income	0.850	–0.055
Factor3	–0.114	1.054	F, Fraser	0.827	0.040
Factor4	–0.120	1.000	P, Polity	0.526	0.103

Note: For N = 1,965 overlapping data, *Main* sample. The shaded sections are the factors of no consequence.

To catch the confluence, the *D-index* of corruption is defined as the corruption index net of the transition: $D_{it} = T_{it} - K^T(y_{it}, 0.3)$. D is negative if the country has 'too' much corruption, and it is positive if the country has 'too' little corruption at its level of development.

When the T-index is replaced by the D-index, in Table 3 it causes the following changes: The income effect disappears, as it should. The correlation to the Fraser index falls to half. The fall is due to a reduction in confluence, but the other half remains. The correlation to the Polity index is stable.

4.2 The negative correlation of corruption and the first difference variables

Column (4) in Table 2 and columns (4), (5) and (6) in Table 3 show the relation between corruption and the three first difference variables g, dF and dP.

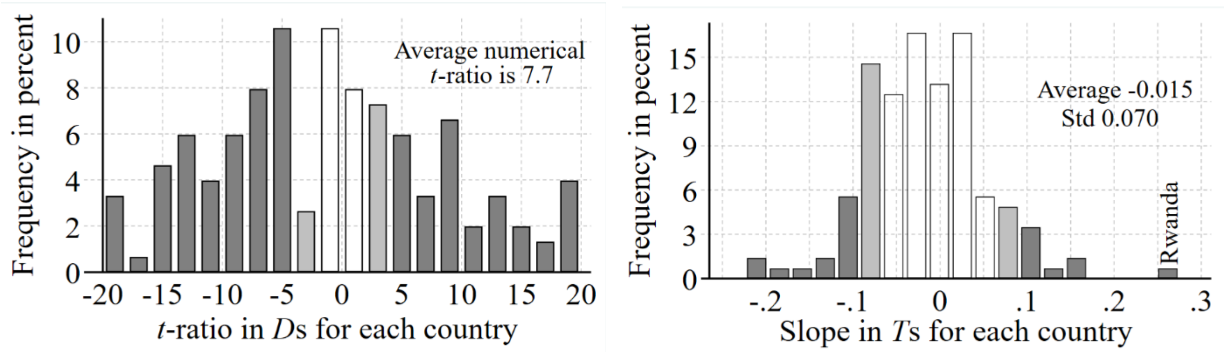
All of these correlations are negative, and most are significant, especially the correlations of T to dF and dP. It is important that institutional changes increase corruption irrespective of the direction of the change. Thus, improvements in institutions, such as steps towards democracy that have a positive effect on corruption in the long run, have a negative effect in the short run. This is the short/long-run contradiction.

4.3 The inertia in the series: corruption levels change slowly

The two indices for corruption, *T* and *D*, have an average number of observations per country of 18.1. Thus, a *t*-ratio can be calculated for the *D*-index for each country to test if the *D*s are permanently above or below the transition curve. The slope in the *D*s can also be calculated by a regression to time for countries with more than five observations. If the slope is negative, it shows a reversion to the mean, which is the transition curve.

Figure 3. Frequency distribution for the *t*-ratios and slopes for *D*s of 166 countries

Figure 3a. Histogram of *t*-ratios — Figure 3b. Histogram of slopes



Note: *T* is corruption and *D* is the same net of the transition. Dark gray bars are for significant observations, and light gray are for mixed significant and insignificant. The *t*-ratios are truncated at $\pm$ 20. At the negative end, the three extreme countries are Taiwan, North Korea and Paraguay. At the positive end, the four truncated are New Zealand, Cape Verde, Sweden and Denmark. Note the strong fall in corruption for Rwanda, which is the seven extreme observations on Figure 1 above the swarm of the observations for incomes 7.2 to 7.5.

Figure 3a shows the frequency distribution of the 166 *t*-ratios. The dark gray bars are thus significant – they are for 64% of the countries. Thus, most countries deviate systematically over more than the two decades from the transition path. This is consistent with Table 5.

Figure 3b looks at the slopes in the *T*-index for the countries. Remarkably few of these slopes are significant, which tallies well with the slow adjustment found. Thus, the analysis shows that the country levels for corruption have considerable stability. It must be due to something that changes slowly. Section 6 assumes that this ‘something’ is institutions.

Another possibility for explaining the stability is culture, which changes very slowly. Unfortunately, it is a soft concept where measurement is difficult, and much is discussed by way of examples. A typical example is the difference in the corruption in the North West with

Anglo-Germanic culture and Southern Europe with Latin-Mediterranean culture. The paper argues that the difference is caused by the fact that Northern Europe became wealthy first, but culture may play a role too. It has also been suggested that culture can be proxied by religion, as analyzed by Paldam (2001), who found that countries with Protestant Christianity do stick out as relatively honest. However, the Protestant countries are the only ones that differ.

4.4 Some panel regressions: the relation is not clear and direct

It would be nice if the fine transition pattern found in section 2.2 could be replicated by a more standard technique. Table 5 shows estimates of three regression models:

(1) $T_{it} = \alpha + \beta_1 y_{it} + u_{1it}$ — T is corruption, y is income, and u residuals

(2) $T_{it} = \alpha + \gamma T_{it-1} + \beta_1 y_{it} + u_{1it}$ — Dynamic version of (1)

(3) $T_{it} = \alpha_t + \alpha_i + \gamma T_{it-1} + \beta_2 y_{it} + u_{2it}$ — the constant is broken into FE (fixed effects)

Table 5. Five regressions of equations (1), (2) and (3)

	(1) Long run	(2) Adjustment	(3a) FE-time	(3b) FE-countries	(3c) L2FE
T_{it-1}, lagged dependent	No	**0.970** (243)	**0.972** (243)	**0.715** (57)	**0.718** (57)
β_1, from equation (1)	**1.363** (58)				
β_2, from equation (2)		**0.036** (4.9)	**0.036** (4.5)	**0.233** (9.7)	**0.236** (6.6)
β^*, from (1) or (3)	1.363	1.212	1.173	0.816	0.837
Constant	**–8.030** (–37)	**–0.184** (–3.3)	**–0.176** (–2.4)	**–1.399** (7.2)	**–1.417** (–5.4)
α_t, FE for time	No	No	Yes	No	Yes
α_i, FE for countries	No	No	No	Yes	Yes
R^2	0.546	0.981	0.982	0.984	0.985
N_i, countries	166	166	166	166	166
N_t, years (maximum)	17 (22)	17 (22)	17 (22)	17 (22)	17 (22)

Note: Estimates with t-ratios above 2 are bolded. The 5 estimates of β^* fall in two groups: Regressions (1) to (3a) find that β^* is very close to 1.33 predicted from Figure 1. Regressions (3b) and (3c) find a long-run slope that is inconsistent with the transition.

Equation (1) is the static cross-country regression that represents the *long run*. Thus, β_1 is an estimate of the steady state effect on income β^*. Equation (2) is the dynamic version of the same equation. The implied steady state, β^*, is found by deleting the lag, so γT_{it-1} becomes γT_{it}, and solves for $T_{it.}$:

(4) $\beta^* = \beta_2/(1 - \gamma)$, — which should be equal to β_1

Regressions (1) and (2) give similar effects, but the adjustment parameter in (2) is $\gamma = 0.97$. This has two consequences. First, the adjustment takes a long time – only 50% is done in 22 years of the data. Second, it is so close to one that it is almost a unit root, which suggests that the estimate is shaky. The estimate of β^* in (1) is therefore better than the estimate in (2); fortunately they are close. Thus, the slow adjustment can be believed, especially as it was also found in section 4.3.

Regression (3c) is the L2FE panel-regressions,[13] which adds fixed effects. Fixed effects for time change little, as there is no international trend in the corruption index. However, fixed effects for countries make the results inconsistent with the transition curve. The data goes from 1995 to 2016, which only contains about 50% of the adjustment. Thus, the *T*-variable of the countries is half-way constant. This explains why the fixed effects for countries 'eat' about 40% of the long-run effect of income. However, this makes little sense.

This result is much the same as found in the literature on the Democratic Transition. While the correlation between the main political system indices and income is strong, the relation disappears when the L2FE-model is applied to the data.[14] Paldam (2020) argues that the L2FE-model is the wrong tool for analyzing *long-run transitions*.

5. Causality is from income to corruption: Two tests

It is notoriously difficult to test for causality in macro data, as they aggregate many different relations, so all we can hope for is to find the dominating direction of causality. As the direction is controversial, the paper uses three tests for causality: The informal test from Figure 2d, a formal long-run two-stage instrument (TSIV) test reported in section 5.1, and a short-run correlogram test that follows in section 5.2. All causality tests are problematic, but fortunately, the three tests tell the same story as regards the causal direction.

5.1 The long-run TSIV-test, using DP-instruments, for development potential

Development has long roots, so the instruments for development should be from before these roots. The DP-variables listed in Table 6 measure the nature-given development potential long before development.[15] While they predict the development of countries rather well, it appears less likely that they can predict the corruption of countries, as it was probably much the same across countries even a few hundred years ago.

[13] In the econometric literature, it is often termed a GDPM regression, for Generic Dynamic Panel Model.
[14] Acemoglu *et al.* (2008) discovered this surprising result for the L2FE-model.
[15] The DP-test is developed in Gundlach and Paldam (2009a), where the variables are more carefully explained and documented. Gundlach and Paldam (2009b) applied the test to corruption and income. The test in Table 7 is run on new data, so it is an independent replication, giving the same results.

Table 6. The DP instrument-variables

The biological variables:
Animals. Number of domesticable mammals weighing more than 45 kilos, which lived in various regions.
Plants. Number of arable grasses with a kernel weight exceeding 10 mg, which grew in various regions.
Bioavg. Average of plants and animals. Each variable was normalized by dividing by its maximum value.
Biofpc. The first principal component of plants and animals.
Maleco. Measure of malaria ecology.
The geographic variables:
Axis. East-west orientation of a country, measured as east–west distance divided by the north–south distance.
Climate. A ranking of climates as to how favorable they are to agriculture by the Köppen classification.
Coast. Proportion of land area within 100 km of the seacoast.
Frost. Proportion of a country's land receiving five or more frost days in that country's winter.
Geoav. Average of climate, lat, and axis, each variable was first normalized by dividing by its largest value.
Geofpc. The first principal component of climate, *lat*, *axis* and *size*.
Lat. Distance from the equator as measured by the absolute value of country-specific latitude in degrees.
Size. The size of the landmass to which the country belongs, in millions of square kilometers.

Note: The idea of the DP-variables and most of the effort to put the variables together are due to D.A. Hibbs and O. Olsson (2004, 2005), based on the suggestions of Jared Diamond (1997). The biogeography data are for 112 countries. If income data are missing for 2005, the next observation within a time interval of +/−10 years is used.

As the *DP*-variables are time-invariant, it only makes sense to use them on cross-country samples. As usual, the cross-country regression (4) is without instruments, while (5) is the TSIV regression with the *DP*-variable as instrument, where, as before, T is corruption and y income. The us are the residuals:

(4) $T_i = \alpha_1 + \beta_1 y_i + u_{1i}$, where β_1 is the simple regression of T and y.

(5a) $y_i = \gamma_2 + \lambda_2 DP_i + u_{2i}$, where DP is the instrument, tested to be good.

(5b) $y_i^D = \gamma_2 + \lambda_2 DP_i$, which is used instead of y_i at the second stage.

(5c) $T_i = \alpha_2 + \beta_2 y_i^D + u_{3i}$, the IV-regression, where y is instrumented.

If the estimate of β_2 is significantly different from zero, a causal link from y to T is established. As the test deals with the long run, the DP-tests use averages over the period 2005-10.[16] The data for these years are unlikely to be revised, so the test should replicate.

Regressions (4) and (5) allow a comparison of the estimates of β_1 and β_2. In most cases β_1 and β_2 do not deviate significantly. This suggests that all of the correlation between T and y is due to the causal relation from y to T. Obviously, β_1 is not precisely equal to β_2, so there is always some leeway to say that there might be some (little) causality the other way.

[16] The period includes both four good years and two crises years, so they are about average.

Table 7. The DP-test for long-run causality from income, *y*, to corruption, *T*, 2005-2010

	Main model	Robustness of model to instrument variation			
Dependent variable:	(1)	(2)	(3)	(4)	(5)
No. of countries	101	106	101	101	142
	OLS estimates, Equation (4)				
Income, *y*	**1.31**	**1.41**	**1.31**	**1.31**	**1.26**
t-ratio	(13.3)	(14.3)	(13.3)	(13.3)	(13.2)
Centered R^2	0.64	0.66	0.64	0.64	0.55
	IV estimates, Equation (5c), *y* is instrumented as per equation (5a and b)				
Income, *y*	**1.51**	**1.60**	**1.48**	**1.37**	**1.25**
t-ratio	(10.0)	(11.5)	(9.8)	(9.8)	(9.2)
Instruments	*biofpc, geofpc*	*bioavg, geoavg*	*animals, plants*	*axis, size, climate*	*coast, frost maleco*
First stage partial R^2	0.44	0.52	0.44	0.50	0.50
CD F-statistic	**39.03**	**55.05**	**39.05**	**32.06**	**45.32**
CD critical value	19.93	19.93	19.93	22.30	22.30
Sargan test	**0.23**	**2.49**	**1.09**	**3.09**	13.06
(*p*-value)	0.63	0.11	0.30	0.21	0.00
	Hausman test for parameter consistency of OLS and IV estimates				
C-statistic	***3.34***	4.03	**2.18**	**0.34**	**0.03**
(*p*-value)	0.07	0.04	0.14	0.56	0.86
	Check for reverse causality				
CD F-statistic	**29.58**	**41.62**	**27.64**	17.89	20.40

Note: All observations for averages of 2005-2010. All estimates include a constant (not reported). To include Ethiopia in the 1995 sample, the 1993 observation for *polity* is used. Belize, Cap Verde, Hong Kong, Iceland, Luxembourg, Maldives, Malta, and Samoa are not included in the Polity IV database. Fiji, Papua New Guinea, and the Solomon Islands are not included in the Maddison database. The estimation results are not significantly affected by the additional observation on Ethiopia.

Table 7 shows a set of TSIV-regressions using the DP-instruments. The Cragg-Donald test and the Sargan test are used to say if the TSIV-regressions are statistically sound.

The *Cragg-Donald* (CD) statistic tests for instrument strength. If it is below the critical value (10 percent maximal size), the instruments are weak. All CD-tests in Table 7 exceed the critical value. Thus, the CD-test shows that the instruments are strong.

The *Sargan* test tests for the joint null hypothesis that the instruments are valid and correctly excluded from the estimate. Here the p-value is reported. It should show that the test is not rejected; i.e. the p-values are above 0.05. Four of the Sargan tests are above the test limits.

The *Hausman* test tests for parameter consistency of the OLS and IV estimates. The test rejects homogeneity, by p-values below 0.05. One of the five tests rejects homogeneity.

The last section in Table 7 tries to detect reverse causality. It runs Equations (4) and (5) in the reverse, explaining *y* by *T*. Here only the Cragg-Donald test is reported. The instruments are weaker in all cases, but three of five are accepted, indicating some simultaneity.

5.2 Correlograms: analyzing short-run causality and the short/long-run contradiction

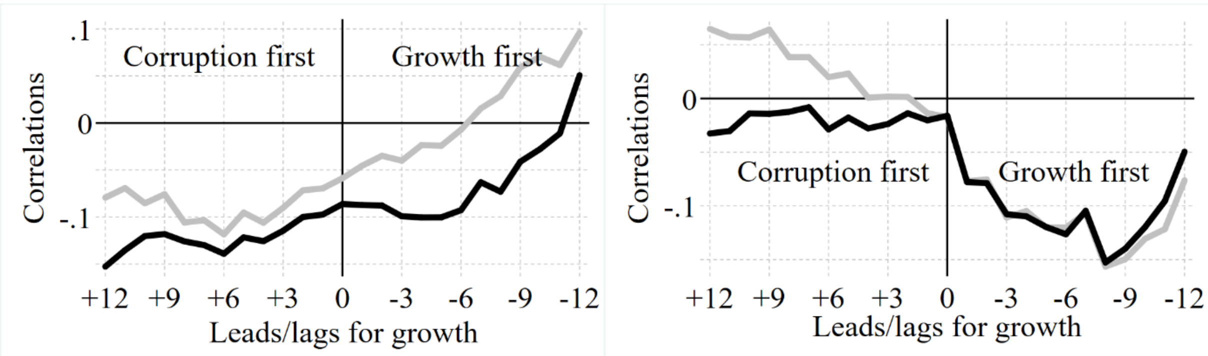
Figure 4 develops the correlations from Table 2 into correlograms. They are calculated independently for each country, with enough data. The figure shows the averages. The data becomes thinner as the lags increase. The intersections with the vertical axis for no leads or lags are the correlations from Table 2. Figure 4a contains the trend due to the transition, so it is difficult to interpret. This trend is deleted on Figure 4b, which uses the *D*-data.

The left-hand side of the graphs shows the effect of corruption on growth. It is significant on Figure 4a, but not on Figure 4b. Thus, the negative correlation from corruption to growth on Figure 4a is due to the long-run trends in the data. The right-hand side of the graphs shows the effect of growth on corruption. On Figure 4a the negative growth-corruption correlation vanishes after 6 to 12 years, and on Figure 4b it is even later than after 12 years, but it does disappear. Thus, the contradiction between the short- and the long-run is temporary.

The asymmetries in correlograms point to causality, and Figure 4b is very asymmetric. The asymmetry is to the right, so once the underlying transition trends are deleted from the data, growth can predict corruption, but not the other way.

Figure 4. Correlogram between growth, *g*, and corruption, *T* and *D*

Figure 4a. For the *T* corruption index | Figure 4b. For the *D*-index, net of the transition



Note: The correlograms are estimated for each country, and the curves are averages. The black curve is for all countries, while the 20 most developed countries and the OPEC countries are deleted for the gray curve. Countries with less than five observations for *T* are omitted.

To conclude: The DP-test shows that the main direction of causality is from income to corruption, but there is likely to be some little simultaneity in the relation. This is confirmed by the correlogram test, and it was also suggested by Figure 2d. These findings tally with the observation that corruption is a much smaller phenomenon than development. The total amount of 'redistribution' caused by corruption is probably less than 5% of GDP in the typical less developed country. Development deals with the whole aggregate that is explained by many factors, where corruption is a small one.[17]

6. Institutional explanations

This section tries to sort out strong confluence. Section 6.1 adds a few more comments to the *F* and *P*-data, and section 6.2 compares the transitions in the *T*-index and the two institutional indices, while section 6.3 reports a set of regressions that tries to sort out the specific effects of *F* and *P* on *T*, which are the effects that are independent of the common transition.

6.1 Data for the political and economic systems: Polity and Fraser indices

The *Polity index* tries to describe the political system on an authoritarian/democratic scale of integers from –10 to +10. This index gives two variables: P_{it} itself and the average numerical difference, dP_{it}.

The *Fraser index of economic freedom* tries to characterize the economic system on a scale from 1 to 10. This index gives two variables, F_{it} itself and the average numerical difference, dF_{it}.[18] *F* started as an annual index in 2000. Consequently, this section works with data that covers the 17 years from 2000 to 2016, and 144 countries of the *Main* sample. As seen from Tables 2 and 4, this does not change the correlation of the two corruption indices, *T* and *D* (that is net of the transition), to income and growth (*y* and *g*).

Tables 2 and 4 also showed that the correlations of both *T* and *D* to the levels of *P* and *F* are positive and rather large. The correlations $cor(T, P) \approx cor(D, P)$, so the relation of corruption and democracy is not spurious, while half of $cor(T, F)$ is due to the common transition. The relations of both *T* and *D* to the three stability measures are all negative and mostly significant. They are always smaller for *D* as expected.

6.2 Comparing transitions: An additional causality indication

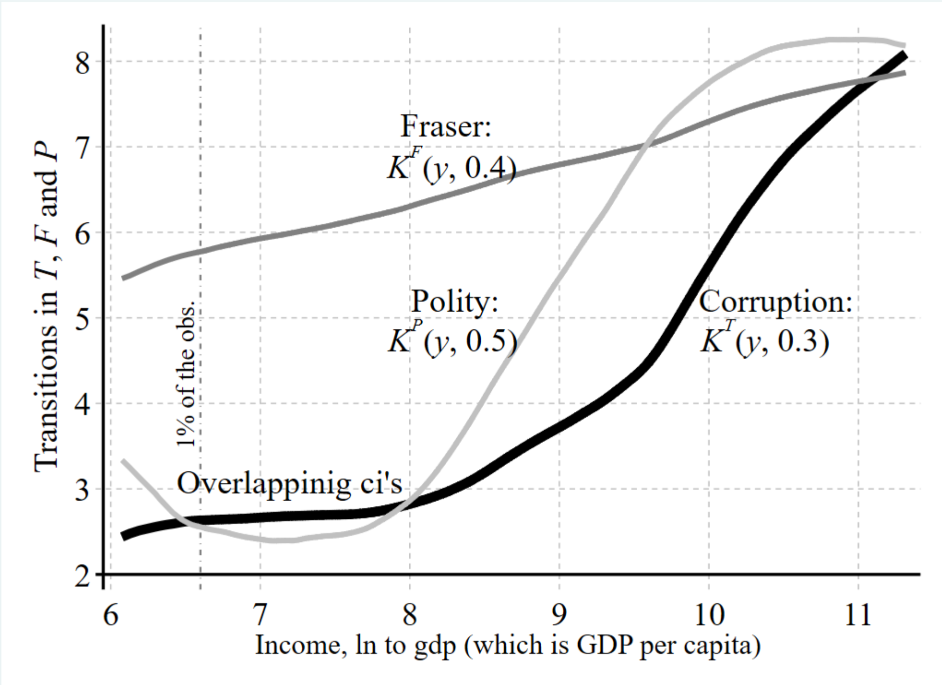
Figure 5 is another way to illustrate the late transition of corruption. The figure compares three transitions estimated on overlapping data for 2000-16:[19] K^T estimates the Transition of Corruption. The curve is almost the same as on Figure 1. K^P estimates the Democratic

[17] The findings in the paper are therefore in accordance with the tail-wagging model of causality. It is the dog that wags the tail, and not vice versa, even when a vigorous wagging may give repercussions moving the dog a little!
[18] The Fraser-index is a measure of the freedom to run a private business. It scores institutions accordingly, so low taxes and few restrictions, law and order, stable money and open borders give high scores.
[19] The transition curves for the Polity and Fraser indices are discussed in more detail in Paldam (2020).

Transition, while K^F estimates the Transition of the Economic System. The dotted vertical line at $y = 6.6$ shows that the low ends of the curves are fragile.

On Figure 1 the old wealthy countries of the North West stuck out as unusually honest. This was interpreted as an effect of time on the internal dynamics of corruption as discussed in section 3.3. Once countries become honest, they get gradually more honest over time.

Figure 5. Comparing three transition estimates: K^T, K^P and K^F, Main sample



Note: Estimated for N = 1,965 for the years 2000-16. The data for $y < 6.6$ are thin. F is the Fraser index for economic freedom, P is the Polity2 index for the degree of democracy, and T is corruption as on Figure 1. OPEC countries are excluded. The confidence intervals for K^P and K^T overlap below 8.2.

The K^P-curve is the transition curve for the Polity index. It looks very much like the K^T-curve, but the K^T-curve is one full log-point of income later than the K^P-curve. This is a difference in GDP per capita of 2.7 times, which is growth in 30-50 years. Thus, first the political system becomes more democratic, and after several decades corruption falls. This is further evidence on the long-run causality from P to T.

The K^F-curve is the transition curve for the Fraser index. It is less clear. The curve has a positive slope throughout, and the confidence intervals (not shown) are narrow. Thus, it does represent a systematic change, but there is no sign of convergence at either end. Unfortunately, the K^F-curve looks as a typical (log-linear) income curve. This explains the strong collinearity in Table 8 that occurs when the F-variable is included. However, given that the F-curve is interpreted as a transition curve, it is clear that it starts to rise well before the K^T-curve has any bend. Thus, it can explain the K^T-curve and support the conclusion that the corruption transition is late and due to transitions in other variables, notably institutions.

Table 8. Seven regressions explaining *T* corruption, and *D* corruption net of transition

	Explaining *T*-index, corruption		Explaining *D*-index, corruption less transition	
	(T1)		(D1)	
	Coef. t-ratio beta		Coef. t-ratio beta	
y, income	**1.33** (14.9) 0.80		0.11 (1.5) 0.13	
Constant	**-7.55** (-9.4)		-0.99 (-1.5)	
R^2	0.63		0.02	
	(T2)	(T3)	(D2)	(D3)
	Coef. t-ratio beta	Coef. t-ratio beta	Coef. t-ratio beta	Coef. t-ratio beta
y, income	**0.88** (7.0) 0.53		**-0.29** (-2.8) -0.34	
P, Polity	0.03 (1.5) 0.09	**0.06** (2.5) 0.17	0.03 (1.7) 0.16	0.02 (1.1) 0.10
F, Fraser	**0.72** (3.9) 0.30	**1.57** (9.7) 0.65	**0.64** (4.4) 0.54	**0.37** (3.3) 0.31
Constant	**-8.61** (-9.2)	**-6.63** (-6.4)	**-1.95** (-2.6)	**-2.59** (-3.6)
R^2	0.69	0.57	0.19	0.14
	(T4)	(T5)	(D4)	(D5)
	Coef. t-ratio beta	Coef. t-ratio beta	Coef. t-ratio beta	Coef. t-ratio beta
y, income	**1.21** (10.6) 0.72		-0.04 (-0.5) -0.05	
g, growth	**-0.11** (-2.1) -0.12	**-0.17** (-2.4) -0.18	-0.06 (-1.5) -0.13	-0.06 (-1.5) -0.13
dP, dif *P*	-0.46 (-1.4) -0.09	**-2.13** (-5.3) -0.40	***-0.49*** (-1.8) -0.19	***-0.43*** (-1.8) -0.16
dF, dif *F*	-1.90 (-1.1) -0.07	**-9.57** (-4.5) -0.34	**-2.73** (-2.0) -0.19	**-2.46** (-2.0) -0.18
Constant	**-5.72** (-4.7)	**6.80** (15.7)	1.11 (1.1)	**0.67** (2.6)
R^2	0.65	0.34	0.08	0.08
	(T6)	(T7)	(D6)	(D7)
	Coef. t-ratio beta	Coef. t-ratio beta	Coef. t-ratio beta	Coef. t-ratio beta
y, income	**0.84** (6.4) 0.50		**-0.34** (-3.2) -0.41	
P, Polity	0.02 (1.0) 0.06	***0.05*** (1.9) 0.13	0.02 (1.4) 0.13	0.01 (0.8) 0.07
F, Fraser	**0.86** (4.2) 0.36	**1.49** (7.4) 0.62	**0.65** (4.0) 0.55	**0.40** (2.7) 0.33
g, growth	**-0.13** (-2.7) -0.14	**-0.17** (-3.1) -0.18	**-0.08** (-2.0) -0.16	-0.06 (-1.5) -0.13
dP, dif *P*	-0.20 (-0.7) -0.04	**-0.76** (-2.2) -0.14	-0.29 (-1.2) -0.11	-0.07 (-0.3) -0.02
dF, dif *F*	0.78 (0.5) 0.03	-0.65 (-0.3) -0.02	-0.66 (-0.5) -0.05	-0.07 (-0.1) -0.01
Constant	**-8.72** (-6.1)	**-5.20** (-3.4)	-1.09 (-0.9)	**-2.53** (-2.3)
R^2	0.70	0.61	0.22	0.15

Note: All regressions are OLS on a consistent sample of 131 non-OPEC countries. The explanatory variables have different scales. To make the effects comparable, beta coefficients are reported. They are the coefficients when regressions are run for normalized series, i.e. where series are transformed to zero mean and a standard deviation of one.

6.3 Regressions as a tool to sort out the confluence

Table 8 is not meant as an estimate of a model, but as an attempt to sort out the confluence. It reports 14 regressions. The seven (T)-regressions explain the corruption index by the variables in the leftmost column; for example, regression (T2) is $T_i = a + bP_i + cF_i + u_i$,, where *a, b* and *c* are the estimated coefficients reported. The seven (D)-regressions are the same, except that *T* is replaced by *D*, the corruption net of the transition.

Two of the variables give stable estimates, though they are not always significant. The first is *P*, Polity, which gives a small positive effect on corruption by both *T* and *D*. Democracy does increase honesty, but not much. The second is growth, which is always negative. The betas for both variables are about 0.15. The coefficients on the remaining five variables change substantially.

Income and *F*, Fraser, have high confluence when explaining corruption, *T*. The betas sum to 0.83 in equation (T2), while beta for *T* alone is 0.80 in (T1). Thus, the two variables explain almost the same, but income is better alone in (T1) than Fraser alone in (T3). From the corresponding *D*-estimates, it is clear that the confluence is generated by the transition as expected from section 2.3. The specific effect of *F* is thus positive, but only moderately large.

The two first difference variables, *dP* and *dF*, are always negative when significant, and mostly also when insignificant. Thus, institutional instability increases corruption in the short run, as does growth. However, also the *dP* and notably the *dF* variable have a great deal of collinearity with the level variables. In the last section of the table with both the levels and the dif-variables, only one coefficient to *dP* is significant – it happens when income *y* is omitted.

A transition is a process of system change. The changes are mainly to the better, so in the longer run corruption decreases. However, the changes are also instability, so in the short run they increase corruption. This is a story of short-run costs versus long-run gains. It points back to the positive effect of income and the negative effect of growth from section 3. If part of the transition is caused by the transitions in the institutional variables, it reinforces the finding that the main direction of causality is from development to corruption, not the other way around.

7. Conclusions

The paper deals with the social ill of corruption. It shows that the ill is due to poverty and uncertainty. Thus, in the long run, corruption is strongly reduced by development, but the process of development requires large changes – also in institutions – that appear as uncertainty, which increases corruption. Countries rarely make only the institutional changes necessary for the transition, but proceed in a more roundabout way, giving much larger changes than necessary, and hence much more uncertainty that increases corruption for some time.

This explains the contradiction between the results in the level variables (*y*, *F* and *P*) and the first difference variables (*g*, *dF* and *dP*). The short/long-run contradiction helps to explain why the Transition of Corruption happens rather late in the process of development.

Most socio-economic variables have transitions, so development is a highly confluent process. Corruption, income, the Fraser index for economic freedom and the Polity index for the political system are all heavily inter-correlated. To the extent the paper has managed to untangle the interdependence, it has appeared that both institutional indices have an independent role explaining corruption. As their transitions happen earlier, this corroborates the causality findings that argue that the main direction of causality is from development to corruption.

By the parable of the horse and the cart, it would appear that development is the horse that should be put in front - to move the cart.

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Appendix 1: Variables, terminology and sources

Variable	Definition and sources
	National accounts variables. Used as development proxies.
Source	Maddison Project: https://www.rug.nl/ggdc/historicaldevelopment/maddison/.
gdp	GDP per capita. The *cgdppc* series. It is marginally better than the *rgdpnapc* series.
y	*Income*, the natural logarithm to *gdp*. One income point is a change of *gdp* of 2.7 times.
g	*Growth* of *gdp.*
	Transition terminology, for index $X = T$, P and F.
X_{it}, X_j	Panel and unified representation of X-variable. Unified data are used for kernel estimates.
$\Pi^X(y)$	*Transition* in X, where X diverges from traditional and converges to modern steady state.
$K^X(y_j, bw)$	*Kernel* regression, with bandwidth bw, used to estimate $\Pi^X(y) \approx K^X(y_j, bw)$
	Transparency International's Corruption Index T and the D-index
Source	Transparency International: https://www.transparency.org/.
T_{it}	T-index [0, 10] for corruption to honesty. Rises when corruption falls, $\partial\Pi^T/\partial y \geq 0$.
D_{it}	The deviation of the T-index from the transition path: $D = T - \Pi^T \approx T - K(y_j, bw)$
	Polity index P and dP; analyzed in Paldam and Gundlach (2018) and Paldam (2020).
Source	Institute for Systemic Peace: https://www.systemicpeace.org/polityproject.html.
P_{it}	P-index [−10, +10], Polity2 for authoritarian regimes to democratic ones, $\partial\Pi^P/\partial y \geq 0$.
dP_{it}	Average annual numerical change in P
	Fraser index of economic freedom F and dF; analyzed in Paldam (2020).
Source	Fraser Institute: https://www.fraserinstitute.org/studies/economic-freedom.
F_{it}	F-index [0, 10], from no economic freedom to laissez faire, $\partial\Pi^F/\partial y \geq 0$.
dF_{it}	Average annual numerical change in F
	Three GCB-indices. Variables used in Appendix 2 only
Source	Polled items from Transparency International's Global Corruption Barometer
B	Item 'Have paid bribes', per 100 people. Polled, decreases when corruption falls
Bn	Item 'If yes, how many', per 100 people. Same polls, decreases when corruption falls
Pe	Item 'Perception of corruption in percent'. Same polls, decreases when corruption falls

Note: The data are downloaded from the said home pages in the fall of 2019. See also references

Appendix 2: Four measures of corruption

Joint work with Jerg Gutmann, Hamburg University, Germany

The corruption index, *T*, used above is problematic. Fortunately, alternative data exist. Gutmann *et al*. (2020) use three alternative datasets; see last section of Appendix 1 for definitions and sources. This appendix discusses how different the data are. All four datasets are from Transparency International, but compiled in different ways. The *T*-index is the standard corruption index, using information from many sources. It has one observation per year per country. The three ***GCB***-indices are from the same set of 473 national level polls, giving 3 *x* 473 aggregated observations, of which 449 overlap by countries and years to the *T*-index. The overlap includes *y*, income, which is the natural logarithm to GDP per capita. We use the 449 overlapping data: T_{it}, B_{it}, Bn_{it}, Pe_{it} and y_{it}, for the same countries *i* and years *t*.

Table A1 shows the correlations of the four corruption measures and income. As the scale is the reverse for the *T*-index and the three *GCB*-indices, the signs should change precisely as they do. Table A1 reports Pearson's normal and Kendall's rank correlations in parallel. The two sets of correlations are proportional, so the distribution of the indices is not important.

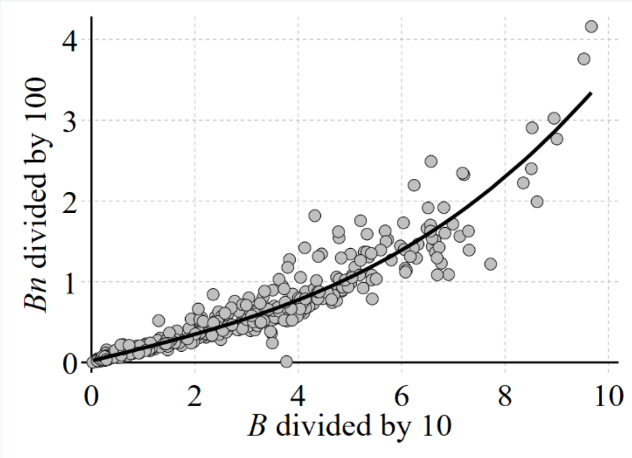
Table A1. Correlation matrices of the four indices and income for 449 observations

	Pearson's correlation						Kendall's rank correlation				
	B	*Bn*	*Pe*	*T*	*y*		*B*	*Bn*	*Pe*	*T*	*y*
B	1.00	0.92	0.42	–0.66	–0.70	*B*	1.00	0.86	0.32	–0.55	–0.54
Bn		1.00	0.34	–0.51	–0.59	*Bn*		1.00	0.30	–0.51	–0.48
Pe			1.00	–0.55	–0.33	*Pe*			1.00	–0.35	–0.25
T				1.00	0.74	*T*				0.98	0.59
y					1.00	*y*					1.00

Conceptually, the four indices fall in two groups: The two bribe-indices, *B* and *Bn*, should be closest related, and they are. The two perception indices, *Pe* and *T*, should be close as well, but they are not. The closest to the *T*-index is the *B*-index. In addition, the *T*- and *B*-indices have large correlations to income, y, while the *Pe*-index has a weaker correlation.

The first question is if the *Bn* data contributes relevant extra information. Figure A1 shows the relation between *B* and *Bn*. The curve included is a fractional polynomial fit. With such a fine fit, it is clear that *Bn* provides little extra information. Furthermore, *Bn* has less correlation to *Pe*, *T* and *y* than has *B*. Thus, *Bn* provides little extra information. Gutmann *et al.* (2020) reach the same conclusion, based on plotting individual level responses.

Figure A1. The relation between *B* and *Bn*



Thus, we disregard the *Bn* data and concentrate on the three remaining corruption variables *B*, *Pe* and *T*. Figure A2 displays the distributions of the three variables, as scatters over income, which is known as the best explanatory variable for the level of corruption. The three scatters are provided with a kernel curve, $B = K^B(y, bw)$, $Pe = K^{Pe}(y, bw)$ and $T = K^T(y, bw)$, where the bandwidth $bw = 0.4$. The curves give the paths of the 'underlying' long-run transitions in the data. As the reader can see from the 95% confidence intervals, these curves are well defined.

Figure A2. The transition of corruption in the three indices

Figure A2a. The standard curve: *T*-index over income

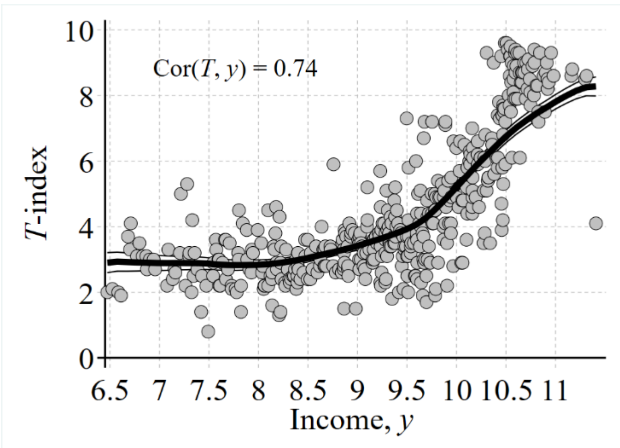


Figure A2b. *B*-index over income

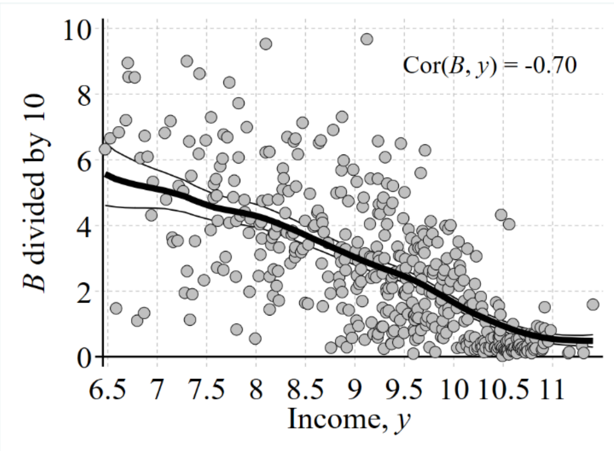
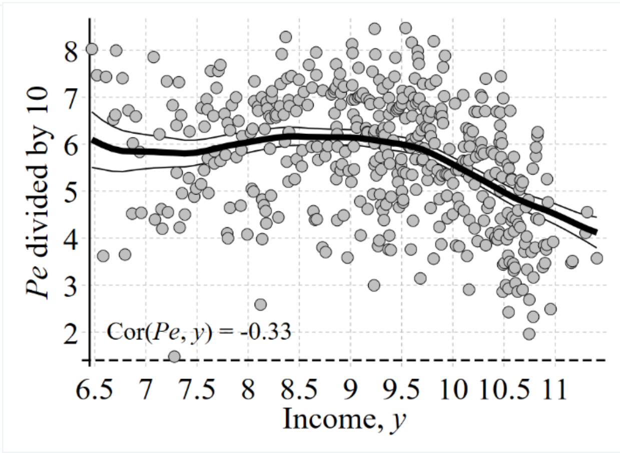


Figure A2c. *Pe*-index over income



Note: The three kernels included are estimated using the Epanechnikov kernel, and the bandwidth is always 0.4. All 439 observations are used. The kernels are surrounded by 95% confidence intervals.

Figure A2a looks very much like Figure 1 in the paper, even though *N* has fallen 6 times from 2,730 in the paper to 449 in this appendix. Once again, it appears that the Transition of Corruption is very robust in the *T*-index. Thus, the path in Figure A2a is the reference path.

Both Figures A2b and A2c also have a significant transition path, where corruption falls when income grows, but the paths do not look very similar. Figure A2c has a transition form that is closest to the reference path. The sign is the reverse, as it should be, and it is flat until approximately $y = 9.5$, when the transition sets in, reducing corruption. However, the observations scatter much more in Figure A2c than in Figure A2a, and the form is less pronounced. It is also interesting that the transition curve in Figure A2b has an almost linear fall, while the reference path has a flat section from $y = 6.5$ to about 9.5, like in Figure A2c.

Figure A3. Two graphs looking at the number of observations *N*

Figure A3a. The frequency distribution for *N*

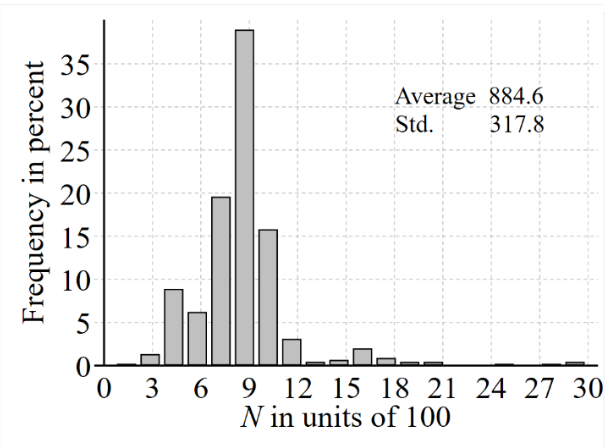
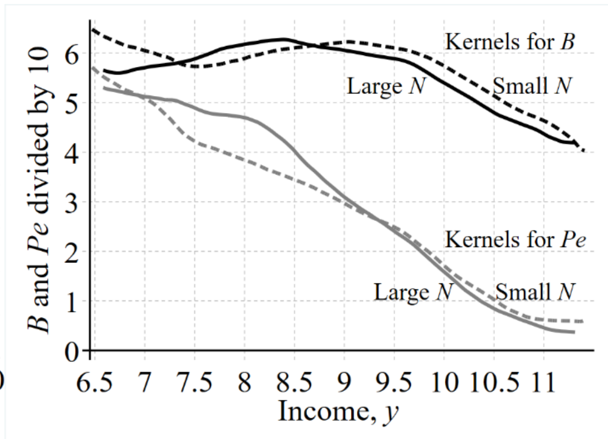


Figure A3b. Kernels for small and large *N*s



One explanation of the excessive scatter in the *Pe*-index may be that the *GCB*-polls have a relatively small number of respondents, as shown in Figure A3a. Figure A3b shows that the transition curves become a little neater if we only use the 50% of the observations with the highest *N*'s. In addition, the *B*- and *Pe*-kernels get to look a little more like each other. Thus, the moderate number of respondents in the *GCB*-polls may explain something, but there is clearly more to be explained.

Thanks to the excess variation in the *GCB*-indices, many cases can be made where the *B*- and *Pe*-indices tell stories that differ from the ones told by the *T*-index. It is clear that corruption is difficult to measure. Nevertheless, the big cross-country patterns in the data are robust to differences in measurement.