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The demographic transition

An estimate of the typical path

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Abstract:

The purpose of this note is to show that the demographic transition looks like a typical transition in the cross-country data of the last half century. The cross-country pattern is somewhat different from the long-run time series pattern. It is discussed how the two patterns are related. The method used in the empirical analysis is scatter plots with kernel regressions.

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The estimates in the appendix are made by Erich Gundlach.

This note considers three curves: The domestic fertility rate, the domestic mortality rate, and their difference, which is the domestic net population growth rate. When depicted over the full transition from a poor LIC to a wealthy DC, it will be termed the G-curve. In a long-run time series perspective the democratic transition is the hump on the G-curve shown on Figure 1. In a cross-country perspective it is the shift between a high and a low level for the G-curve shown on Figure 2.

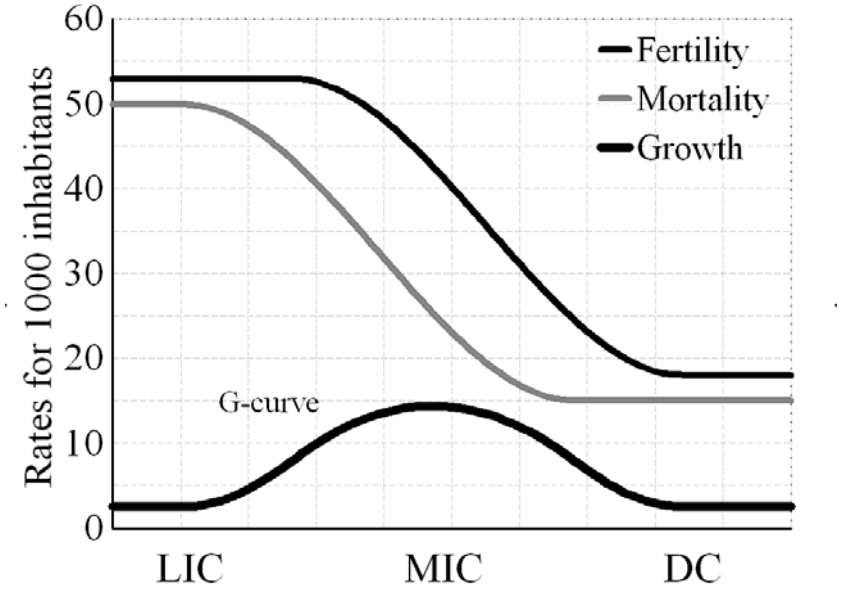
The paper use two theoretical concepts: A transition is a process that changes the level of a variable from a stable traditional one to a stable modern one. The equivalence assumption claims that the long-run and the cross-country pattern is the same. The demographic transition is a typical transition, but it does not support the equivalence assumption.

The paper has five sections: (1) discusses the theoretical curves on Figures 1 and 2; (2) describes the cross-country data used; (3) looks at the empirical pattern in birth and death rates; (4) considers the empirical G-rate; and finally (5) discuss the equivalence assumption. The appendix gives some estimates.

1. The time-series and the cross-country perspectives

The demographic transition is well-known textbook material. It is typically depicted as Figure 1, where the G-curve is the difference between the fertility and mortality curve.

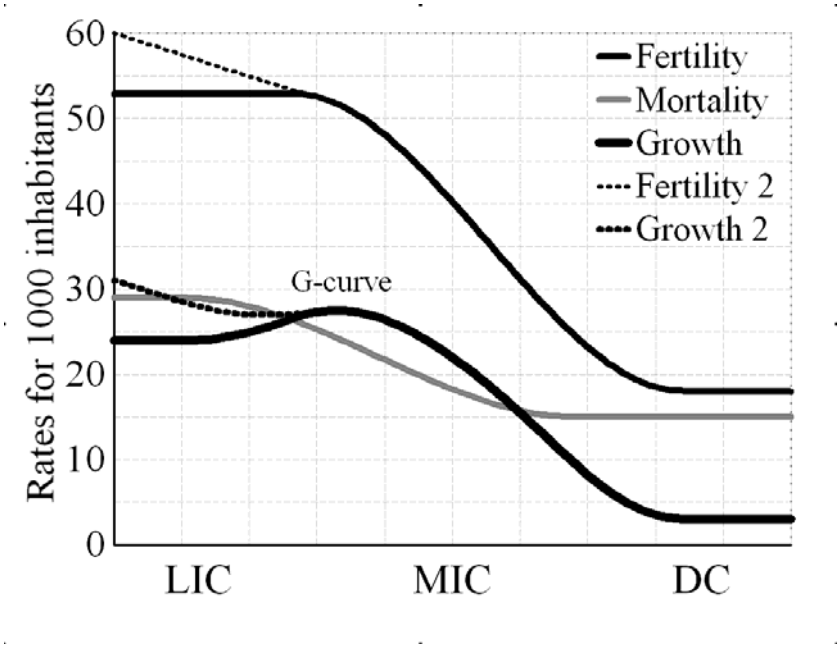
Figure 1. The long-run time series perspective on the demographic transition



In the long run population grows very slowly, so the G-curve is flat and low. In traditional society (LIC) it comes about by a high rate of fertility and an almost similarly high rate of mortality. In modern society (DC) both fertility and mortality are much lower, but the difference is about the same. However, mortality falls before the fall in fertility, so during the Grand Transition countries go through a period of high fertility and low mortality. This is shown by the hump on the G-curve.

This description is fine as regards long-run time series, but it has a problem with the cross-country data from the last half century. Due to globalization the progress in modern medicine has become – at least partially – available in the poor countries. This has allowed a much faster fall in mortality than in the historical data. Thus, Figure 2 shows the picture for the cross-country data where the mortality curve is shifted down in the poor countries. The early fall in the death rate reduces the hump on the G-curve.

Figure 2. The cross-country perspective on the demographic transition



Modern medicine may also have increased fertility (as per the fertility 2 curve) in the LIC countries, so the small hump on the G-curve may not be visible at all. Hence, Figure 2 shows a version of the demographic transition that looks very much like the standard transition curve, starting in poor countries at a high level and falling to a low level in the wealthy countries. Both the traditional high and the modern low levels may be fairly stable.

2. The data from 1960 to 2008: 10 periods of 5 years

Figures 3, 4 and 5 consider the scatter of two data sets:

On the horizontal axis is the *initial income* data, defined as the natural logarithm to Maddison data for GDP per capita for 10 years 1960, 1965,…, 2005.

On the vertical axis is the corresponding *5-year average for a demographic series*: 1960-64, 1965-69,…, 2005-08, where the last period covers data for 4 years only. These data do not vary very much within each country over the 5-year periods, so even if the WDI holds only one observation for a time period, it is included.

Figure 3 shows the (crude) birth rate and Figure 4 the (crude) death rate per 1000 people from the WDI. Thus, to get the rates into percentage points, pp, the numbers should be divided by 10. Figure 5 is net population growth calculated as the difference between the birth and the death rate. The three rates are net of in- and outmigration in the countries. Table 1 shows the number of observations available.

Table 1. Number of potential and available observations

Countries	157	Gaps in % of
Potentially 10 *x* 157	1570	potential
	Actually available	
Initial income (Maddison)	1438	8.4%
Each demographic series (WDI)	1553	1.1%
Overlapping data for both series	1436	8.5%

Table 2. Some averages: The data depicted are for the bottom row "Others"

Group	Number	Birth rate			Death rate			Net growth		
		Average	St dev	T-ratio	Average	St dev	T-ratio	Average	St dev	T-ratio
All	1436	31.21	13.59	2.30	11.91	5.79	2.06	19.41	10.74	1.81
4 rich oil[a]	40	31.13	10.71	2.91	6.84	5.56	1.23	24.49	7.35	3.33
Others[b]	1396	31.22	13.66	2.28	12.06	5.73	2.11	19.27	10.78	1.79

Notes: (a). The 4 rich oil countries are Kuwait, Qatar, Saudi Arabia and UAE. (b) Depicted on Figure 3.

These data allow us to estimate the three curves of Figure 2. The data contains the development from 1960 to 2008. This development is partly a result of the growth (and decreases) of income in the period and partly independent of income – the latter part is disregarded in the

analysis. Consequently the dramatic fall in fertility in Eastern Europe in connection with the change of economic system after 1990 is treated as noise. Fortunately these countries are an income range where many other countries are located. If these countries are excluded, it reduces the noise, but it does not change the basic picture.

However, Table 2 singles out four rich oil countries which are for some of the years the richest in the world, but they are rich without having passed through all the changes in society that constitutes the Grand Transition. If they are included, they make the kernel-curves turns up at the extreme right hand side. In Table 1 it appears that they have a high level of population growth (and in addition they do have a high level of immigration). They are excluded on Figures 3 to 5.

The three scatter diagrammes are provided with a kernel-curve that is taken as the first approximation to the transition curve for the three series. It is estimated by a kernel regression as defined in the note to the figures. A kernel regression is a continuous estimate of a MA-process with a fixed bandwidth – on all three curves it is 0.25. It is a rather small bandwidth that should allow all systematic movements in the average to show up, however the picture shown is robust to changes in the bandwidths up to 1 where the curves become almost straight lines. The advantage of the kernel curve is that it makes the form of the average curve visible to the naked eye without the contraints of a particular mathematical formulation.

3. The paths of the birth rate and the death rate during the transition

Figures 3 and 4 show the path of the crude birth and death rates. The kernel-curves look much as expected from Figure 2. It should be noted that below the income level of 6 the curves are supported by so few observations that they are unreliable.

The curves are termed “crude” as they are unadjusted for the form of the population pyramid. The form of the pyramid does affect the death rate so that it becomes flat “too” early as it also reflect the number of young people in the population. People in the same age cohort has a higher death rate till quite far to the right on the income axis.

Compared to the theory in Figure 2 we note the the flat section of the curves in the traditional societies (the LIC countries) is not very flat. It just have a less steep slope. Modern medicine is spreading rapidly. But as both birth rates and death rates have a similar slope the net effect is likely to look fairly flat as indeed it does. Finally note that the birth rate keeps falling throughput the range, though the slope declines at the end.

Figure 3. The path of the birth rate on 5-year data for 157 countries, 1960-2008

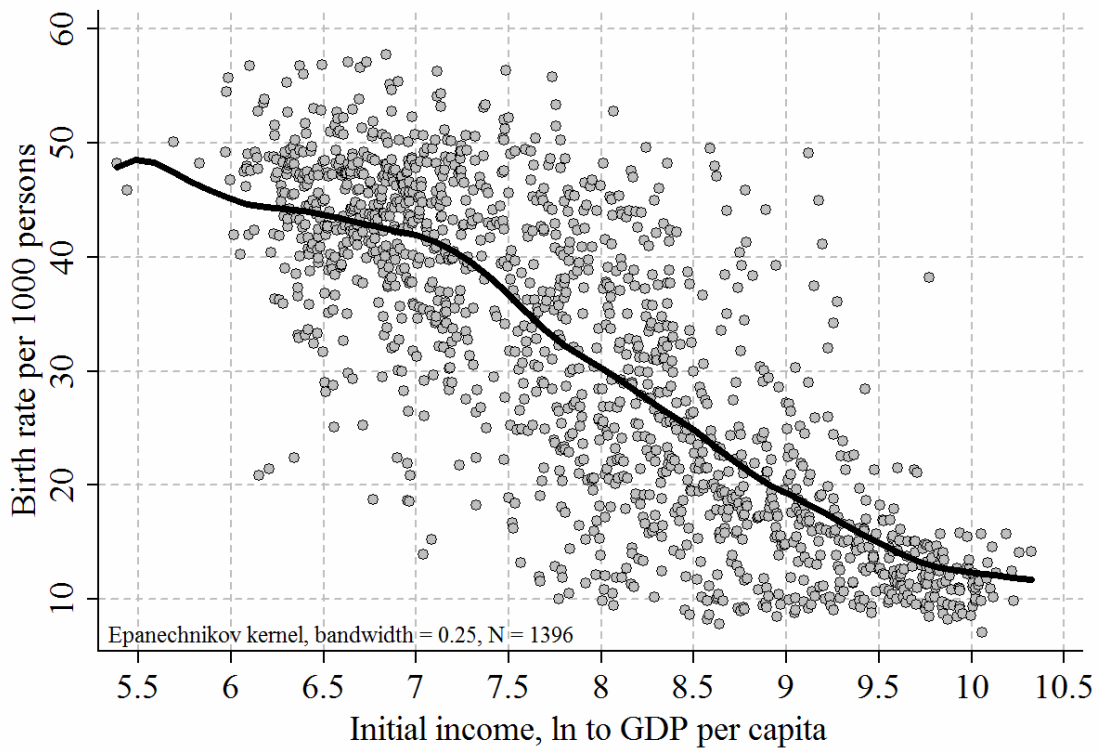
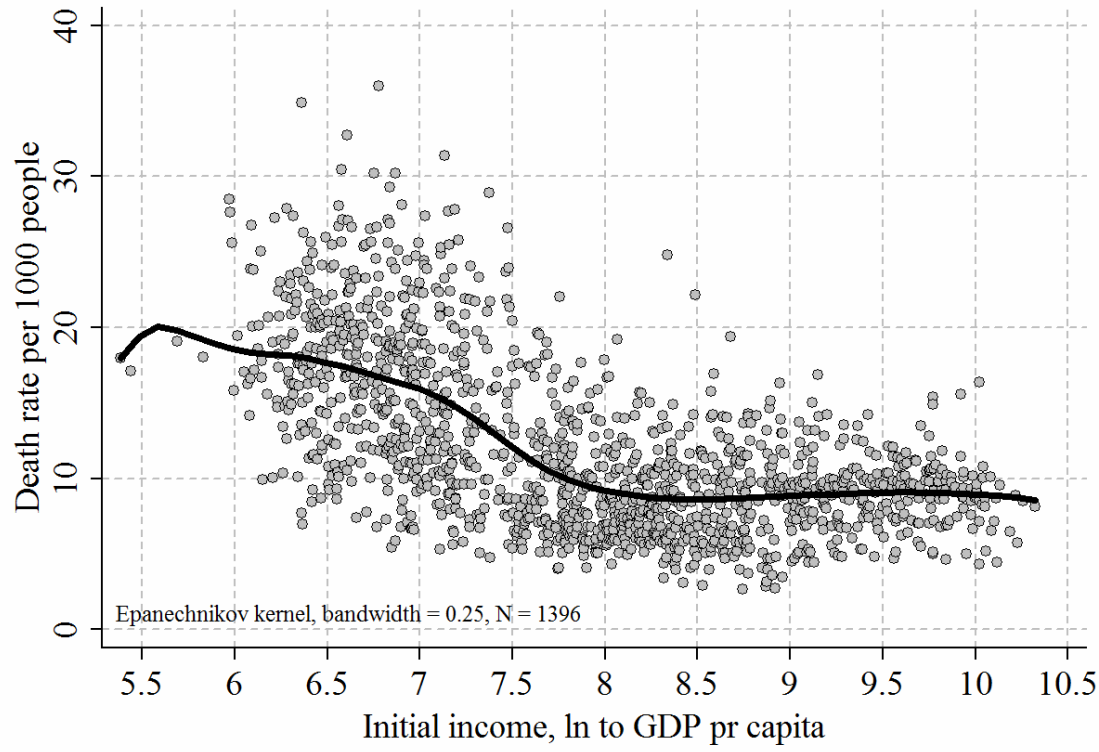


Figure 4. The path of the death rate on 5-year data for 157 countries, 1960-2008



4. The transition: An estimate of the cross-country G-curve

The G-curve should be the difference between the curves on Figure 3 and 4, and even when it is estimated all over from the data it is very much as it looks on Figure 5. It starts with a high, and rather flat, level of about 26 in the LIC countries and falls fairly smoothly till it reaches a flat level of about 3 in the DCs. Table 3 gives the orders of magnitudes.

Figure 5. The demographic transition on 5-year data for 157 countries 1960-2008

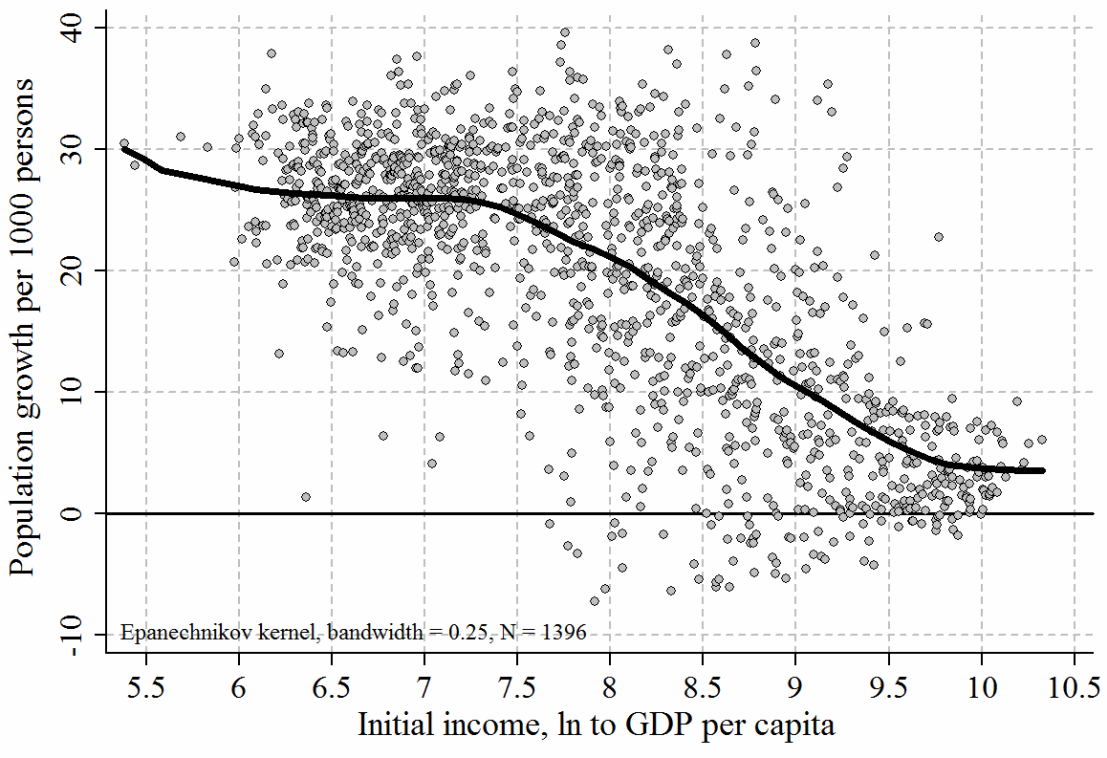


Table 3. The two levels of the curve

Levels	Income y	Net population growth	Countries at kink point in 2005
Traditional constant	$y < 7.25$	$26.2 \approx 2.6\%$	Laos, Senegal and Ghana
Transition	$7.25 < y < 9.75$	Falling	
Modern constant	$9.75 < y$	$3.3 \approx 0.3\%$	Israel, Trinidad, Estonia

Perhaps it should be noted that the nice looking transition curve on Figure 5 is a bit of an artifact. This, in particular, applies to the flat section in the low income countries that hide a fall in both the birth and the death rates. It is no wonder that it has been endlessly researched – especially in connection with world population forecasts.

The theoretical Figure 2 catches the empirical estimates in Figures 3 to 5 reasonably well. It is obvious that we understand the grand pattern demographic transition in the cross-country data. However, Figures 3 to 5 also show a rather dramatic scatter of the observations around the average pattern.

5. Some reflections

A set of papers by Erich Gundlach and the author builds on the *equivalence assumption* that the long-run time series pattern and cross-country patterns in the data are the same. Section 1.2 in Paldam and Gundlach (2010) gives some argument why this assumption is reasonable. It is therefore interesting that the demographic transition is a transition where the equivalence assumption has to be treated with some care.

It is arguable that the difference is due to the unobservable parts of the of the low end – that is if we had more observations below 6 lp on the income axis it would have looked like on Figure 1. However, a great many life saving drugs and inoculations have been made available to poor people, so there has been a great fall in mortality in poor countries. The main point is that even when the curves on Figures 1 and 2 have the same qualitative form, the mortality curve shifts so much down on Figure 2 relative to Figure 1 that the traditional equilibrium becomes a high growth level.

We do know, however, that Figure 1 is well in accordance with historical facts, and Figure 2 is confirmed by Figures 3 to 5.

References:

The papers in my project with Erich Gundlach.

Working papers and background papers are available from http://www.martin.paldam.dk

1 Paldam, M., Gundlach, E., 2008. Two Views on Institutions and Development: The Grand Transition vs the Primacy of Institutions. *Kyklos* 61, 65-100

2 Gundlach, E., Paldam, M., 2009a. Farewell Primacy. The political system and the economy. *European Journal of Political Economy* 25, 340-54

3 Gundlach, E., Paldam, M., 2009b. The transition of corruption: From poverty to honesty. *Economic Letters* 103, 146–48

4 Paldam, M., Gundlach, E., 2010a. The Democratic Transition: A study of the causality between income and the Gastil Democracy index. Accepted for publication in the *European Journal of Development Research*

5 Bjørnskov, C., Paldam, M., 2010. The spirits of capitalism and socialism. A cross-country study of ideology. Accepted for publication in *Public Choice*

6 Paldam, M., Gundlach, E., 2010b. The Religious Transition. A long-run perspective. Working paper (under refereeing)

7 Gundlach, E., Paldam, M., 2010. The agricultural, demographic and democratic transitions. Two estimations models with the reverse results. Working paper, September

Sources (data used are downloaded around May 1st 2010):

Maddison, A., 2003. *The World Economy: Historical Statistics.* OECD. Paris

They were updated till February 2010 a month before Angus Maddison passed away on the Maddison home page http://www.ggdc.net/maddison/

WDI, World Development Indicators from the World Bank, URL: http://devdata.worldbank.org/dataonline/

Appendix: Some estimates

Section 4.3 of Gundlach and Paldam (2010) reports a set of estimates of the transition path, using the same models as in the Table that differs from the one in the paper in two ways:

(a) The paper brings the results for the 5-year averages only. Here they are supplemented with panels of 3-year averages and 7-year averages.

(b) The paper includes observations where 1 of the yearly data is missing. Here they demand that all observations are available, and the last period ends in 2008 even when the 3- and 5-year periods do not fit so that a few of the first years are not included.

The Base model (1) gives a rather precise linear estimate of the change showed on Figure 5 of the transition of 23 per mille points over 4 to 4½ logarithmic income points. The results in the paper cited show a somewhat complex causal structure and the estimates in the Table are complex too: The results in Columns (1), (5) and (6) are close to each other and to the ones in the paper cited. Columns (2), (3), (5) and (7) give unstable results as the lagged endogenous variable is very close to 1. Column (4) gives results with a clear pattern showing that that the two fixed effects replaces most of income in the estimates.

Table. The Background-B-Table for the demographic transition

Dependent variable: P_{it}	Base model	AJRY model	Mixed model variants				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
			3-year averages				
β_1 on income, y_{it-1}	**-6.35**	**4.25**	**-24.89**	**-1.88**	-5.62	**-4.62**	**-14.49**
	(-40.6)	(2.0)	(-3.1)	(-6.8)	(-1.4)	(-16.7)	(-5.7)
Number of observations	2217	2217	2217	2217	2217	2217	2217
			5-year averages				
β_1 on income, y_{it-1}	**-6.45**	**9.37**	**-24.33**	**-1.50**	31.76	**-4.52**	**-14.34**
	(-31.1)	(2.5)	(-2.0)	(-4.0)	(0.6)	(-11.4)	(-4.1)
Number of observations	1238	1238	1238	1238	1238	1238	1238
			7-year averages				
β_1 on income, y_{it-1}	**-6.56**	15.79	-24.00	**-0.98**	-23.17	**-4.20**	**-14.14**
	(-26.2)	(1.5)	(-1.7)	(-2.1)	(-1.1)	(-8.0)	(-3.6)
Number of observations	828	828	828	828	828	828	828
			Characteristics of model				
Lagged dep. variable, P_{it-1}	no	yes	yes	no	yes	no	yes
Country fixed effects	no	yes	no	yes	yes	yes	no
Time fixed effects	no	yes	no	yes	no	no	Yes

The estimates of the AJRY model in column (2) produces 3 – very different – positive coefficients, of which 2 are significant. In the paper this model gives a coefficient very close to zero. It is obvious from the Figure 5 that none of these results make sense. Our interpretation of these results is that they point to serious problems with the AJRY model.