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A Cross-Country Causal Panorama of Human Development and Sustainability

Importante

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Abstract

A broad summary of the theoretical literature on economic growth shows that this theory has transcended the neoclassical paradigm and that market rationality does not govern the human development process. Instead human development is the appropriate standard for rationality. Using Gidwitz et al's (2010) database of human development index (HDI) components (income, life expectancy, literacy, gross enrolment ratios, 1970-2010) for 135 countries, together with indicators of the demographic transition, urbanization, technological change, sustainability, and institutions (15 variables), I construct a panel for the 1985-2010 quinquennia, instruments for the same variables using the 1970-1980 data and conduct a descriptive dynamic analysis. The HDI distribution is broadly twin-peaked, corresponding to the demographic transition. I construct a matrix of causal interactions between the 15 variables, using three types of instrumented regressions for each matrix entry: a) *levels regressions;* b) *growth regressions;* c) *growth regressions also containing the contemporary growth of independent variables. This analysis is repeated for 3 subsamples obtained according to HDI levels and another 3 according to technological levels. The Hausman and Sargan test results show a ranking of endogenous determination and indirect impacts of the variables on each other that varies qualitatively for levels and growth and across HDI and technological levels. I also conduct regression sets* (a) *and* (b) *for the main sustainability indicators. The results are discussed in the light of a survey of the recent empirical literature on human development, which also highlights human development as freedom. The main development transitions are broadly advancing at different stages: fertility, infant mortality, the dependency ratio, literacy, enrolment, life expectancy, urbanization, varying substantively across HDI and technological levels. Also, there is a transition towards more democracy and less autocracy. However, at very low HDI levels income per capita decreased.*

The main policy suggestions for promoting the demographic and human development transitions are to support: technology transfer to the poor, investments not supplied by the markets (human capital, urbanization, sustainability), the emergence of democracy, and global governance. Sustainability is supported by the demographic transition and requires the development of renewable energy, as proposed in the Green New Deal, with an emphasis on electricity.

Keywords: Human development, demographic transition, technology transfer, democracy, causality.

Resumen

Un resumen amplio de la literatura teórica sobre el crecimiento económico muestra que esta teoría ha trascendido el paradigma neoclásico y que la racionalidad del mercado no gobierna el proceso del desarrollo humano. En lugar de esto, el desarrollo humano provee en sí mismo el estándar apropiado de racionalidad. Utilizando la base de datos sobre los componentes del índice de desarrollo humano (IDH) (ingreso, esperanza de vida, alfabetización, tasas brutas de inscripción, 1970-2010) para 135 países, de Gidwitz et al. *(2010), conjuntamente con indicadores de la transición demográfica, la urbanización, el cambio tecnológico, la sustentabilidad, y el desarrollo institucional (15 variables), construyo un panel para los quinquenios 1985-2010 y llevo a cabo, en primer lugar, un análisis descriptivo dinámico. La distribución del IDH tiene, en términos generales, dos picos, que corresponden al estado cualitativo de la transición demográfica. La información de 1970-1980 provee instrumentos para las 15 variables causales. Asimismo, construyo una matriz de interacciones causales entre las 15 variables, para lo cual utilizo tres tipos de regresiones instrumentadas para cada entrada de la matriz:* a) *regresiones de nivel;* b) *regresiones de crecimiento; y* c) *regresiones de crecimiento que también contienen la tasa de crecimiento de la variable dependiente. Este análisis es replicado para tres submuestras obtenidas de acuerdo con los niveles del IDH y otras tres submuestras obtenidas de acuerdo con un índice de nivel tecnológico. Las pruebas de Hausman y Sargan muestran que la importancia de la endogeneidad y de los impactos indirectos entre las variables varía cualitativamente entre las submuestras, tanto en las regresiones de niveles como en las de crecimiento. También muestro los resultados para regresiones de tipo* a *y* b *para los principales índices de sustentabilidad. Los resultados se discuten a la luz de una reseña de la literatura empírica reciente sobre desarrollo humano, tasa de inscripción, esperanza de vida, y urbanización, que también destaca el desarrollo humano como afirmación de libertad. Las principales transiciones del desarrollo, fertilidad, mortalidad infantil, la tasa de dependencia, alfabetismo, tasa de inscripción escolar, esperanza de vida, y urbanización, están transcurriendo en diferentes etapas. El punto en que se encuentran estas transiciones varía de manera sustancial para diferentes niveles del IDH y de tecnología. También existe una transición hacia más democracia y menos autocracia. Sin embargo, a niveles muy bajos del IDH el ingreso per cápita ha disminuido.*

Las principales propuestas de política para promover las transiciones demográfica y de desarrollo humano consisten en promover la transferencia tecnológica hacia los pobres, inversiones no provistas por los mercados (capital humano, urbanización, sustentabilidad), la transición democrática, y la gobernanza global. La sustentabilidad es promovida además por la transición

demográfica y requiere del desarrollo de recursos energéticos renovables, como propone el "Green New Deal", con un énfasis en la electricidad.

Palabras Clave: Desarrollo Humano, transición demográfica, transferencia tecnológica, democracia, causalidad.

Introduction

What should be the main features of a global policy for human development and sustainability? It is now about twenty years since the neoclassical revival in economics came into full swing, together with globalization. Policies were centered on economic growth rather than human development, as the 1990 Human Development Report expressed. While liberalization unleashed a huge potential for development, it also originated an unprecedented crisis. Economic forces have induced tremendous growth but also concentrated wealth, left many behind, brought the environment to the brink, and led to an economic crisis. Can the main causal features of global development and sustainability be identified so as to provide a basis for policy?

Thirty years of study since the neoclassical paradigm became dominant do indeed provide a basis for policy, whose results also requires a change of paradigm to a more objective point of view, complementing market deficiencies with public action. In particular the neoclassical paradigm does not sufficiently explain nor provide for three of the fundamental processes of development: the demographic transition, technological change, and democratic governance. Moreover, deficiencies in these key aspects of development are also key contributors to unsustainability.

The initial theories of economic growth that emerged with the neoclassical revolution extended the perfect market paradigm to the intertemporal context. While they predicted convergence, from the first they found divergence instead (Barro, 1991). Since then the study of economic growth has consisted of expanding the paradigm so as to explain the wide range of progress, human development, and inequality across countries. In trying to explain the data, the original conception that economic growth consisted fundamentally of a process of capital accumulation, or industrialization, was expanded to include the roles of human capital, technology, institutions, population growth and economic integration. All of these factors interact in the process economic growth and human development, and not all of them function through competitive market mechanisms.

The theory of economic growth highlights the importance of diverse social processes including human development, the demographic transition, technological change, urbanization, institutions and economic integration, as well as sustainability. Can the main causal interactions between these various *aspects* of economic growth be identified? The new UNDP data base (Gidwitz et al, 2010) on human development indicators for the period 1970-2005, including 135 countries, complemented with development data from the World Bank, provides an opportunity to simultaneously address the matrix of interactions between these multifaceted aspects, as well as of their impact on sustainability.

In what follows I first discuss how the current theory of economic growth addresses the interaction of the various aspects of economic growth. This shows that the current theory of economic growth goes beyond the neoclassical paradigm and motivates the definition of human development. Then I review the literature on the current dynamics of human development. Next I give an empirical analysis of the mutual causal interaction between the various aspects of economic growth, and of their impact on sustainability. This analysis is summarized to outline its broad features, which also outline the broad features of a global policy for human development and sustainability.

Addressing sustainability requires major action and therefore presents a major challenge in global governance. The long-term perspective taken here is consistent and complementary with proposals such as the Green New Deal, but also highlights the demographic transition, technological change, and the transition to democracy, as key components of human development and sustainability.

1. Causal Factors in Economic Growth and Human Development

Many variables have been studied in the convergence literature focusing on economic growth and development. A country's economic performance is akin to an orchestra in which every instrument plays its part. It seems clear that if any aspect of a country's performance is poor, it will affect the functioning of the whole, and that each part depends significantly on the others. Even so, much effort has been dedicated to trying to discern underlying, fundamental causes of economic growth, with inconclusive results. In fact, what really matters is finding what variables can be a handle for policy.

There are enough conclusions about global economic growth and development that can be made from the theoretical and empirical literature to establish a general causal framework.

The first is the non-trivial conclusion that economic growth is the result of an equilibrium process. Equilibrium trajectories exist and countries finding themselves below them tend to grow faster. This is the main conclusion of the convergence literature: a robust negative conditional convergence coefficient that should not be overstated. It only implies a narrow form of convergence that can be compatible with converging to development, divergence, or stratified growth. It can be thought that a relevant set of country variables determines the level and growth rates of the equilibrium trajectories. Generally, the equilibrium levels of economic variables that are dynamic under the action of markets, such as capital investment, are functions of the less dynamic variables, such as human capital or institutions. Since economic growth is an equilibrium process, when some barrier is lifted, or some set of inputs provided, that has made a country lag behind its potential equilibrium

level, it will grow faster. This can explain both lesser and major episodes of sustained growth.

The second is that there are growth effects and level effects. Here the point is to distinguish between transitional and permanent growth. Transitional growth exhausts itself as a potential equilibrium level is reached, to a level defined by other variables. Thus capital and human capital may need to be accumulated, institutional and technological possibilities achieved, the environment sustained, before an equilibrium trajectory is reached. Permanent growth rates, however, depend only on the rate of adoption or innovation of technology. No matter how good the institutions, how efficient the education and health systems, how frugal and prudent the population, if technology ceases to improve only some maximum per capita welfare is possible. In fact, this is what the Solow (1956) model shows. Howitt (2000) shows that the convergence of some groups of countries and the divergence of others can be explained by the theory of technological change. This does not exclude level variables such as institutions from being essential determinants of technological change, or appropriate policy handles.

The third observation is that countries differ in their population growth and in timing and duration of their demographic transition. There can be divergence in population growths. In the econometric analysis that follows the demographic transition turns out to be the fundamental backdrop of development.

Thus in the theoretical literature on economic growth there are only two basic mechanisms of divergence between countries.

The first is divergence in population levels. The endogenous theory of fertility predicts that when returns for human capital are high parents will choose to have less but better qualified children. However, near subsistence an increase in income will raise fertility. Returns to human capital differ between countries mainly because technological levels differ between them, a fact lying beyond the assumptions of neoclassical economics. One consequence is that specialization through trade in cheap labor as opposed to human capital, one of the historical features of the global economy, can result in "trading population for productivity" (Galor & Mountford, 2008). Countries specialized in human capital will advance technologically and reach a population equilibrium while countries specialized in cheap labor will progress much slower technologically while their population growth rate will remain high. Urban-rural trade can produce similar effects (Vollrath, 2009; Strulik & Weisdorf, 2008).

The second mechanism is divergence in technological levels. Howitt and Mayer-Foulkes (2005) model underdevelopment and development as distinct steady states in technological change. Their model predicts three steady states, a high one with a high capacity for innovation, a middle one with a good capacity for technological adoption but a low capacity for innovation,

and a low one characterized by a very low capacity of technology adoption. This characterization can be confirmed empirically (Castellacci, 2008; Mayer-Foulkes, 2006). Through their impact on innovation, poor financial institutions can also produce divergence in levels and growth rates (e.g. Aghion et al, 2005).

Both of these divergence mechanisms essentially work through the returns to human capital. The present study therefore includes in its causal analysis fertility and infant mortality (because what matters in endogenous fertility models is an expected net reproduction rate) and a technology indicator.

One of the consequences of the demographic transition is changes in the dependency ratio, which measures the average number of dependent people, both old and young, supported by the adult population. Bloom, Canning and Sevilla (2003) show that when fertility rates first drop the dependency ratio, which we also include in the study, falls and offers an opportunity for savings and investment, the *demographic dividend*.

Having distinguished between growth effects and level effects we can now look at the full causal framework of economic growth and development, summarized in Table 1.

TABLE 1. CAUSAL CATEGORIES OF ECONOMIC GROWTH AND DEVELOPMENT

	POLITICS	INSTITUTIONS	ECONOMICS	GROWTH
Domestic	Political Regime	Supporting Private Goods	Production	Innovation
	Inequality	Supporting Public Goods	Human Capital	Fertility
	Economic Policies		Urbanization and Infrastructure	Distance to Steady State
			Sustainability	
International	Area of Influence	International Agreements	Economic Integration	
	Inequality		Geography	

Innovation, fertility and distance to the steady state are the main variables affecting growth rates. Equilibrium growth rates and distance to the steady state in turn depend on the levels of the main aspects of the economy, summarized as production (including its intertemporal aspects such as arrangements for saving and investment), human capital, urbanization, sustainability, economic integration (e.g. trade and FDI) and geography. In turn these aspects are based on both institutions and the political system. Institutions support the production of both private and public goods. Politics, which both reflect and interact with inequality, have important impacts on human capital, technology and other economic policies and on several kinds of infrastructure investment. Now, most of these variables refer to the

domestic level. If we fully included the international level we might include such variables as area of influence, international agreements and international inequality, for example in technological and human capital levels.

One question that arises in observing Table 1 is the extent to which market policies can bring efficiency to the different aspects of economic development and their interrelations. So long as market power is not very significant, a questionable hypothesis, market policies can make production, trade and FDI more efficient, and therefore also increase incentives for investment in human capital and innovation. However, in themselves the main characteristics of human capital, technological change, urbanization and sustainability, result from market failures, market power and/or externalities. Inequality tends to be untouched by market processes, except when some fundamental asset such as human capital is subject to convergence. Politics and institutions, while depending on wealth and its distribution and subject to the excesses of self-interest, are not economic processes governed by the market.

It follows that the process of economic growth and human development is a political, institutional and economic process that is not governed by an inbuilt process of social rationality and efficiency, such as could be ascribed to a competitive market with an equitable initial distribution. The economic literature on human development devotes considerable attention to this wider set of determinants that require careful and purposeful definition and action.

2. The Concept of Human Development

The very concept of *human development* addresses the need for social rationality by defining a social preference over the outcomes of economic, political and institutional growth and development. Summarizing 20 years of discussion, Alkire (2010) defines it as follows:

> Human Development aims to expand people's freedoms — the worthwhile capabilities people value — and to empower people to engage actively in development processes, on a shared planet.
>
> People are both the beneficiaries and the agents of long term, equitable human development, both as individuals and as groups. Hence Human Development is development *by* the people *of* the people and *for* the people. And it seeks to do so in ways that appropriately advance equity, efficiency, sustainability and other key principles.

The concern with an appropriate definition of human development making justice to its multidimensionality has led to considerable discussion on its

measurement. Alkire and Foster (2010) and Kovacevic (2010) propose methods to reflect in the HDI the distribution of human development achievements across the population, and across dimensions. Alkire and Santos (2010) define a multidimensional poverty index (MPI) composed of ten indicators for education, health and standard of living, indicating that 1,700 million people in the world live in acute poverty. Herrero, Martínez and Villar (2010) define a new Human Development Index, substituting the arithmetic mean by the geometric mean, as a way of expressing the complementary of the HDI components and introducing distributive considerations It also allows introducing new variables for health and education to obtain a higher sensitivity of the index with respect to the differences between countries that are particularly relevant for highly developed countries. Ivanov and Peleah (2010) examine the relevance of agency and freedom to human development for countries from the former socialist bloc. They find first that agency and freedom are the best long-term investment in human development opportunities, but also that subordinating human development to consumer demand generates problems. Cheibub (2010) suggests indicators to include measures capture the political and civil environment within which individuals must pursue their goals. Graham (2010) examines some of the difficulties of including happiness as a measure of human development.

Gaye and Jha (2010) examine sub-national, national and regional reports, finding several novel ways for improving the human development index that can potentially be replicated at the global level. Pagliani (2010) shows that national and sub-national HDRs have promoted the human development paradigm, policy formulation and assessment, the revision of policies and budget allocations, as well as generating media and educational attention. Burd-Sharps et al (2010) show the continued relevance of the HDI to affluent countries. De la Torre and Moreno (2010) extend the calculation of the HDI to the individual and household level, and include additional dimensions such as being free from local crime, absence of violence against women, and inequality. Harttgen and Klasen (2010) also provides a method to calculate the HDI at the household level, allowing the estimate of HDI inequality by population subgroups and household socioeconomic characteristics. Desai (2010) concentrates on women's empowerment, arguing for a wide spectrum of considerations taking into account violence against women and HIV/AIDS in addition to formal employment, education, political representation, waged labor, fertility decline and maternal mortality.

Gayeet al (2010) explain how the Gender Inequality Index reveals how human development is curtailed by gender inequality, and how different elements of gender inequality affect country rankings. Knowles and Lorgelly (2002) include female and male education in a neoclassical growth model, which they estimate on a cross section of countries using long time averages of the data. The results support the importance of female education in raising

labor productivity. Klasen (1999) use cross-country and panel regressions to show a considerable impact of gender inequality on economic growth. Gender inequality in education lowers the average quality of human capital, reduces investment and prevents progress in reducing fertility and child mortality rates.

Engineer, King and Roy (2008) suggest that the income component of HDI should be considered net of education and health investments; otherwise the implicit double counting of these concepts produces suboptimal results when HDI is considered as an objective function in planning.

3. The Dynamics of Human Development

It is not possible to conceive of policies for sustainability that do not at the same time promote the human development (including the demographic transition), and vice versa. The dynamics of each have to be understood if policies promoting both are to make sense. What are the current dynamics of human development, and how do they relate to the theory of economic growth? What can be said about political and institutional change? I review here some of the literature on the dynamics of human development. In the next section I review the interrelation between energy, sustainability, and human development.

On the relation between income and human development, Molina and Purser (2010), using a previous version of the database used here, with less countries, find that the income and non-income components of HDI change have a near-zero correlation, and that income is not a significant determinant of HDI change once urbanization, fertility and female schooling are included. They check their results using years of women's suffrage as an instrument for changes in gender relations, and find that it is a significant predictor of HDI progress for the whole sample. For instance, McGuire (2010) shows that the introduction of a gender quota for the lower house of the provincial legislature in Argentina had a statistically significant and substantively strong association with lower infant mortality. Summarizing, Molina and Purser find that human development trends from 1970 to 2005 fit with the longer term trend of demographic and population change. As they cite, demographic transitions, urbanization and declining fertility rates have accelerated life-expectancy and literacy achievements over the past half-century (UNDESA, 2009a). The occupational aspect of the gender transition is important on its own and combines with the fertility transition (Galor and Weil, 1996).

Applying a dynamic panel data model with state-dependent coefficients to the same database, Binder and Georgiadis (2010) find that HDI and GDP exhibit conditional but not unconditional cross-country convergence. They also find that economic policies such as physical capital investment, government consumption and trade openness have differing impacts across

countries that may spur GDP but have less pronounced effects on HDI, which adjusts much slower and requires its own set of development policies.

Gidwitz et al (2010) confirm continued divergence in per capita income, but find convergence in the human components of HDI. They do not find significant correlation between growth and non-income HDI. Countries underperform in the presence of HIV, low social expenditures and low democracy.

Noorbakhsh (2006) questions findings of HDI convergence, showing that when population weights are used in estimating HDI convergence, results shift from convergence to polarization in the human development index amongst developing countries but a slight reduction in world inequality.

Anand and Ravallion (1993) summarize the relation between income and HDI succinctly, showing that for basic health, average affluence matters to the extent that it controls the incidence of lower income poverty and better public services.

Mayer-Foulkes (2010a) carries out a cross-country analysis of convergence and divergence in human development on the Gray and Purser database. He finds that development consists of a series of superposed transitions each taking off with increasing divergence and then converging. Decomposing the causes of divergence and convergence, he finds urbanization is one of the leading significant variables for human development, with increasing returns for growth, stronger than trade, FDI and economic institutional indicators. The benefits that institutions coordinating urbanization and human capital investment can yield for human development are highlighted.

Turning to analyze the impact of policy on human development, Morocco, Lambert, Ravallion, and Van De Walle (2007) apply an additive decomposition method to aggregate human development in Viet Nam. They find that changes in outcomes were due to structural changes, rather than economic growth or income redistribution, such as public policy efforts at increasing enrollments and increases in the overall economic returns to schooling, as well as knowledge about those returns.

Studying rapid socioeconomic structural change through industrialization and urbanization in East and Southeast Asian growth since 1990, Liu and Yin (2010) explain that while these processes offer enormous room for human development, to successfully seize these opportunities appropriate institutions and public policies are needed, as well as public participation in policy making and implementation. Public policies ensure equitable distribution and contribute to the legitimacy of institutions and social cohesion. They find six principles are critical to a successful HD strategy: agricultural and rural development to facilitate structural transformation and to increase employment; human capital accumulation to promote continued economic and income growth; inclusive urbanization to reduce dualism and enhance social integration; cleaner industrialization to ensure sustainability;

people's participation and empowerment to improve decision making and governance; closer regional and international cooperation to ensure a better future for all on our fragile planet.

Trying to discern appropriate policy mixes, Ranis and Stewart (2010) observe that countries successful at improving the HDI had good or moderate educational enrolment ratios; good or moderate female/male enrolment ratios; and good or moderate Human Poverty Indices. The other three major inputs into success appear to be growth, social expenditure and income distribution. Weak performers all experienced poor or moderate economic growth and had either low income with weak growth, poor distribution and high poverty; or were transition countries where economic, institutional and demographic disruptions led to poor progress.

The role of inequity has received increasing attention. Grimm (2011) investigates the effects of inequality in health on economic growth in low and middle income countries, using panel data covering 62 low and middle income countries over the period 1985 to 2007. He finds a substantial and relatively robust negative effect of health inequality on income levels and income growth, controlling for life expectancy, country and time fixed-effects and a large number of other effects that have been shown to matter for growth. The effect also holds if health inequality is instrumented to circumvent a potential problem of reverse causality. Kanbur (2000) argues that country case studies and disaggregation are necessary to fully examine the impact of inequality on economic growth.

Addressing the impact of information and communication technologies (ICTs), Hamel (2010) examine their potential impact on human development. They note that a recurrent observation in the literature on this topic is that ICTs alone cannot improve peoples' lives; the use of ICTs needs to occur within broader strategies that are tailored to make the most use of these tools and techniques in order to reap their potential benefits for human development and ensure their accessibility for the poor. In displacing previous technologies, the introduction of ICTs may involve downsides, tradeoffs. Significant financial resources may be needed to ensure people-centered strategies and technologies are used.

Political science has also examined cross country human development. Harding and Wantchekon (2010), summarizing the findings of 20 years of research on the causes of human development, state that democracy causes, but is not caused by, economic development. While economic growth is no higher as a result of democratic institutions, these are more conducive than non-democratic alternatives to a more equal growth of income, longevity and knowledge, or health and education. Democracy has these effects because public goods provision is higher due to their provision of accountability structures rendering politicians accountable to the electorate. These

structures offer but does not guarantee the opportunity for human development in the absence of factors such as information and participation.

Vollmer and Ziegler (2009), carrying out a static panel analysis over the period 1970 to 2003, show that democracy is good for human development and this independently from its effect on economic development. Their results strengthen both the median voter theory and Sen's democracy argument. Democracy leads to more redistribution in favor of health provision in more unequal societies.

In trying to understand these impacts, Jayadev (2010) examines the implications for human development of democratic accountability as well as institutional experimentation (most closely associated with the work of Amartya Sen) and the imperative of institutional experimentation (theorized most extensively by Roberto Unger) in the context of global governance.

Walton (2010), however, argues that long-term human development is jointly driven by capitalist dynamics and state functioning. The big issue is whether this joint behavior is oligarchic, extractive, exploitative and divisive as opposed to inclusive, innovative, accountable, responsive and effective at mediating distributional conflict. This can be conceptualized in terms of the nature of the political equilibrium, or, alternatively, the way in which social contracts work. While policy designs of course matters, the ways in policy and institutional choices work, and indeed the choices societies make, is intimately linked to the nature and functioning of the underlying social contracts that in turn shape capitalist dynamics and state behavior.

Taking the position the human development does drive an institutional transition, Welzel, Inglehart and Klingemann (2002) define Human Development as a coherent syndrome of social progress, consisting of socioeconomic development, cultural change and democratization, three components whose common focus is broadening *human choice*. They analyze World Values Surveys and show (1) that the syndrome of individual resources, self-expression values and effective rights is universal in its presence across nations, regions and cultural zones; (2) that this Human Development syndrome is shaped by a causal effect from individual resources and self-expression values on effective rights; and (3) that this effect operates through its impact on elite integrity, as the factor which makes given rights effective.

In another study, Welzel and Inglehart (2001) test Przeworski and Limongi's (1997) argue that transitions to democracy do not derive from economic modernization, finding evidence to the contrary. They also test Inglehart's (1997) finding that modern mass attitudes play a negligible role in promoting regime change to democracy. To the contrary again, they find mass-level liberty aspirations has an even stronger positive impact than economic modernization. Their data covers 60 societies representing nearly 50 per cent of all regime changes in the world since 1972.

On the issue of sustainability, Moran et al (2008) find only one country with an HDI index of 0.8 and a per capita Ecological Footprint less than the globally available biocapacity per person. They also find an overall trend in high-income countries over the past twenty five years that improvements to HDI come with disproportionately larger increases in Ecological Footprint. Some lower-income countries, however, have achieved higher levels of development without a corresponding increase in per capita demand on ecosystem resources.

Neumayer (2010) shows that many of the lowest performing countries on the HDI also face problems of weak unsustainability, as measured by genuine savings. Countries with high to very high HDI performance, on the other hand, typically appear to be strongly unsustainable, as measured by ecological footprints, mostly because of unsustainably large carbon dioxide emissions. Two of the biggest challenges facing mankind this century will be to break the link between high human development and strongly unsustainable damage to natural capital on the one hand, requiring a very significant and rapid decarbonisation of their economies, and assisting countries with very low human development to overcome weak unsustainability by raising their investment levels into all forms of capital on the other.

Jha and Bawa (2006) show that the effect of human population growth on the rate of deforestation in biodiversity hotspots is higher when the HDI is lower.

Pineda (2010) shows that natural resource abundance has been positively and significantly correlated with HDI improvements, except for Latin America.

Touching on the possibility of poverty traps, Mayer-Foulkes (2008a) defines a human development trap that can exist in the context of technological change and gives evidence for its existence in Mexico. This kind of trap can interact with technological traps in the context of globalization, slowing development and giving rise to conflicting interests between supporting human development and supporting technological change, when both require public expenditure (Mayer-Foulkes, 2010b). In this model investing in human capital makes known technologies available to the poor, while investing in technology makes new knowledge available to the educated. In the context of globalization, divergence and stratification in human development can also arise from local geographic and institutional externalities (Mayer-Foulkes, 2008b).

Last but not least, we make some points on the relation between energy, sustainability and human development.

Energy is key to economic development. Cheap energy in the form of fossil fuels dynamized economic growth in developed countries since about 1800. It is only the rise in the global demand for energy and the advent of climate change risk that has brought the availability and sustainability of cheap

energy into question. This has raised the prospect that energy scarcity could impact on human development.

Climate negotiations have aimed to reduce global carbon dioxide emissions. This goal is often seen to be in conflict with providing the world's poorest with modern energy services. Instead, considering renewable energy as the primary aim, the Global Green New Deal initiative (AtKisson, 2009, following UNDESA, 2009b) proposes a global Big Push to subsidize the cost of renewable energy, promote its rapid deployment in developing countries, and through its wide use obtain sufficient cost reductions to make it the default option over other energy sources. The aim of the initiative is to end energy poverty, contribute to economic recovery and growth across countries, and help avoid dangerous climate change.

4. The Data

We now turn to our evaluation of the current dynamics of human development and sustainability. It turns out that the exploration of the data points out the fundamental role of the demographic transition.

4.1. Main variables

The main dataset is Gidwitz et al's (2010) database on the human development index components, per capita income, life expectancy, literacy and gross enrolment ratios, as well as the Hybrid Human Development Index (HDI). This panel ranges over 135 countries over the period 1970-2010. I selected 5 yearly data for the period 1970-2010. This data was complemented with data from the World Development Indicators (2010) and Polity IV (2009).[1] The WDI explanatory variables cover the following categories: sustainability, institutions, trade, physical geography technology and economic geography. Independent variables included from the WDI are urbanization (the only economic geography indicator for a sufficient sample), risk premium on lending, fertility, infant mortality, log population to represent scale effects, the dependency ratio as an indicator of demographic transition impacts (Bloom, Canning & Sevilla, 2003), foreign direct investment inflows (FDI) and trade as percentages of GDP.[2]

Following Castellacci (2008), who bases his classification of countries into convergence clubs on the production of scientific articles per million and literacy, I construct a technology index TECH using a polychoric principal

[1] The Polity IV Project was originated by Will H. Moore and is currently available at the Center for International Development and Conflict Management at the University of Maryland. Special values -66, -77, -88 used to represent various exceptions are replaced here with 0. We use the 2009 update.

[2] Missing values for fertility, trade, FDI inflows, inflation infant mortality and risk premium were treated as follows. Missing values were replaced by 0, and a dummy variable indicating missing values with a one was included.

component analysis of number of articles, number of computers, internet subscribers patents by residents, R&D researchers and technicians, mainline telephone subscribers and mobile telephone subscribers, each of these as a proportion of the population. Where the information is unavailable, it is set to zero and a dummy is defined indicating the missing observations. Some of these indicators give rise to missing entries in the polychoric correlation matrix in which case they are omitted.

For the regressions, TECH is substituted with

$$TECHrel = (TECH - TECHMAX) / (TECHMAX - TECHMIN),$$

where TECHMAX is the maximum technological level for each period. The reason is that the distance to the frontier is both a measure of how far a country is from its steady state and the relevant variable in endogenous technology models (see for example Aghion et al, 2005).

The polychoric methodology is also used to construct two sustainability indices. The first, ECO, is based on energy related indicators together with Ecological Footprint and Ecological Balance. The second, LANS (log of the principal component), is based on per capita Adjusted Net Saving indicators. Missing information is treated as before. The corresponding histograms are even more skewed. Figure 1 shows cross-country histograms for these indicators. The difficulties involved in constructing sustainability indices that are related to human development are examined by Fuentes-Nieva and Pereira (2010).

The resulting coefficients for the three polychoric estimates are shown in Table 2. Note all of the coefficients have the correct signs (Ecological Balance is a good, not an evil), with the sustainability indices actually indicating the opposite concept. Figure 2 shows the relation between the technological index and the Hybrid Human Development Index. Figure 3 shows histograms of each indicator independently.

For the institutional indicators we resort to the current Polity IV database (accessed February, 2011. The main index of this database, Polity2, combines six indicators, Regulation of Chief Executive Recruitment, Competitiveness of Executive Recruitment, Openness of Executive Recruitment, Independence of Executive Authority, Executive Constraints, Political Competition and Opposition, Regulation of Participation, and Competitiveness of Participation. Polity2 is defined on a scale from –10, representing autocracy, to 10, representing democracy.

Figure 4 shows there is an inverted U relation between the HDI and Polity2, with all missing and exceptional observations representing interruption, interregnum and transition periods concentrated at 0. I therefore define two variables, Autocracy and Democracy, each on a scale from 0 to 10, with a Dummy for missing and exceptional values. Table 3 shows

that these indicators are associated with the HDI, its components, fertility and infant mortality. Democracy systematically gets a better score than Autocracy, which nevertheless obtains a positive score. Governance thus seems to matter. If one imagines that under autocracy leaders are under some kind of Darwinian selection process in which the benefits they offer their society count, this explains the positive scores. A negative sign on fertility implies families are finding human capital investment more attractive.

Table 3 also shows that once Autocracy and Democracy are present, Executive Constraints, an indicator often used in economic studies of institutions, is not significant under democracy, only under autocracy. Therefore I do not include this indicator.

The length of time that Polity2 has not changed. Durable, is also included in the estimates. Inflation and risk premium are included as additional institutional variables related to macroeconomic management.

To allow for clustered error estimates in subsamples, the number of variables needs to be restricted. Hence the geographical variables are restricted to region (East Asia Pacific, East Europe and Central Asia, Middle East and North Africa, South Asia, North America and Western Europe, Sub Saharan Africa and Latin America and Caribbean) and latitude.

A fixed HIV indicator was constructed equal to recent HIV prevalence in adults.

UNDP has developed inequality measures for health, education and income, used for adjusting the HDI. Unfortunately these are only available for 2010 so these three indicators can only be used as fixed rather than dynamic factors.

An index for the human capital component of the hybrid HDI can be constructed, namely HUMx = LIFEx^½ EDUx^½, where the small x means this is an index from 0 to 1 and EDUx is GERx^½ LITx^½ rescaled from 0 to 1. Figure 5 shows three pairwise scatter plots between HUMx, logGDPx and fertility. The first scatter plot between HUMx and logGDPx shows evidence of a Human Development transition that begins when the income index is around 0.25 and ends when it reaches around 0.6 (see arrow in the first figure). It turns out that this transition is intimately related to the demographic transition. The second scatter plot between Fertility and logGDPx shows evidence of a Fertility transition at the same levels of the income index (see arrow in the second figure). The third scatter plot shows HUMx plotted against Fertility. The result is almost a precise inverse linear relation between the two variables, corresponding to the theoretical description of endogenous technology. The correlation between HUMx and Fertility is –0.8759, while the OLS regression R2 is 0.7672. What the three figures corroborate is that the twin-peaked transition in HDI reflects the demographic transition.

Confirming the human development transition and its relation with income and fertility, Figure 6 shows a histogram for HDI, by categories 0.05 wide

centered on the indicated value (in the index scale from 0 to 1), with corresponding mean log GDP per capita, mean rate of change of HDI, and fertility. The frequency line shows the distribution is twin-peaked, as is also documented in Mayer-Foulkes (2003), a study on life expectancy convergence clubs, and in Mayer-Foulkes (2006), which incorporates to these clubs the transitions between them and GDP per capita measures. The line showing the rate of change of HDI shows that the barrier between the two clubs consists of a region of slow HDI growth. For a study of these two regimes in life expectancy dynamics see Canning (2010). Georgiadis, Pineda and Rodriguez (2010) show that the impact of income on life expectancy differs across these two regimes, being stronger for higher health, while Pritchett and Viarengo (2010) maintain the importance of income for countries with lower health levels as well. In this regard, it is interesting to note that while there is a growing consensus that many health improvements in poor countries are relatively cheap (Bloom and Canning, 2008), the reasons they do not reach the poor may be poor provision of public goods, implying the Preston curve may have an institutional component. The convergence clubs are also visible in Figure 24 and 28 of Hidalgo (2010), particularly the yellow trajectories. However, these studies do not mention the relation with fertility that has been shown in Figure 5 and is also apparent in the fertility curve in Figure 6.

Unfortunately the data used for adjusting the HDI for inequality is only available for 2010, and is thus used only as three fixed inequality effects, for health, education and income. Also, there was not enough information to include the gender and inequality transitions as factors of human development.

4.2. Subdividing the sample

As mentioned before, I subdivide the sample as a way of studying the nonlinearities with the averages provided by the coefficients of linear regressions. To see how coefficients of the linear growth and level regressions differ across subsamples. So that the number of variables used in each regression not approach the number of clusters in each subdivision, it was best to divide the sample in three equal parts. This was done according to HDI and TECH in 1985. The subdivisions are plotted in Figure 7, showing how they correspond to the HDI transition described above.[3]

In the case of the HDI subdivision the samples coincide approximately with the lower club, the transition group and the higher club, except that the middle club contains countries that might not enter the transition. The TECH clubs also coincides, albeit less closely, with this subdivision, but reflects the

[3] It is interesting to note that Binder and Georgiadis (2010) also define three clusters of countries, but using two very different variables, gender inequality and institutional development.

fact that some countries have relatively high HDI but low TECH for their group or vice versa.

Descriptive statistics for all of the variables are provided in Tables 4 for the full sample and in Table 5 for each of the subsamples.

5. Methodology

The objective of this paper is to analyze the mutual causal interaction between human development, the demographic transition, urbanization, technological change, sustainability, institutions and technological change at the cross-country level. The economic literature has shown that the process of growth is full of interactions between these various categories of variables, generating a highly complex system. Even individually the processes the variables follow are often nonlinear transitions. In a paper examining many of the same variables as this one, Mayer-Foulkes (2010a) shows that development consists of a series of superposed transitions, with divergence followed by convergence. Examples are the literacy and schooling transitions, the urban transition, the demographic transition, transitions in health, and institutional and technological transitions.

These transitions become apparent in graphs plotting the standard deviation against the mean of selected development indicators by groups of countries. Figures A.1 to A.6 forming Appendix A shows graphs similar to those presented in Mayer-Foulkes (2010a), this time for the 135 countries of Gidwitz et al's (2010) database and for the variables used in the present study. Four groups of 34 countries were defined (except for the last group with 33 countries) according to their HDI and GDP index levels in 1970.

Autocracy, Democracy, Fertility, Dependency Ratio and Infant Mortality provide clear cut examples of transitions (*ibid*).

Economic growth is therefore a highly nonlinear process. This is one reason why linear regression studies have been highly inconclusive (Levine & Renelt, 1992; Sala-i-Martin, 1997). Yet nonlinear estimates tend to be highly complex. I take two approaches in this respect. The first is to split the sample and see how coefficients of linear regressions differ between samples. The second is to include the instrumented contemporaneous growth rates of independent variables, together with their levels, to measure impact of excess or unpredicted growth, as occurs during a transition.

6. The regressions

I describe here the three types of regressions that were used to estimate human development dynamics. The first two types are also used for estimating the sustainability indicators and will be stated precisely below.

The first type were *level regressions* showing the dependence of each variable on the contemporary levels of the others, following the idea of a production function, as follows. Let Y_{it}^{j}, j = 1 to N, represent a system of N variables, with i the country and t the time period. Suppose in the long term the level of each depends on the others, and also on some additional exogenous variables Z_{it}^{j}, j = 1 to M. Then

$$Y_{it}^{j} = \sum_{\substack{1\le k\le N,\\ k\neq j}} \beta_k Y_{it}^{k} + \sum_{1\le k\le M} \alpha_k Z_{it}^{k} + u_{it}^{j},\ j = 1, \ldots, 5. \qquad (*)$$

Because the independent and dependent variables are determined simultaneously by the same process, they are endogenous, so the independent variables were instrumented on four variables: the average of their own level and rate of growth over the period 1970-1980, and these two variables multiplied by t = 1, …, 5, representing the current quinquenium (1985 to 2005). The independent variables were instrumented one by one in separate regressions. The idea behind these instruments is that the level and rate of change of each of the variables over the period 1970-1980 allows a prediction of these variables over the period 1985 to 2005, independent of the shocks occurring in this period. The interaction of the initial levels and rates of growth with the time variable in effect lets the first stage estimates be a numerical integration of the variable in question that includes an estimate of the rate of change of the rate of growth as a function of the initial level and rate of change of the variables (as predicted for example by the theory of convergence). Because in fact all of the variables are endogenous and interact through time, the instruments could be correlated with errors of the dependent variable transmitted through other variables across time from the 1970-1980 decade to each of the quinquennia between 1985 and 2005. Therefore we use only the results for which these errors are small as established by the Sargan test, so that the instrumented coefficients are representing direct effects.

The dependent variables were HDI, LIFE (expectancy), LITERACY, GER (gross enrolment ratio), logGDP (per capita), logPOP (ulation), FERT (ility), URBAN (percentage of the population), TECH, ECO, LANS, DEMOCRACY, AUTOCRACY, TRADE and FDIIN (flows). The instrumented variables were LIFE, LITERACY, GER, logGDP, INFMORT, logPOP, FERT, DEPEND, URBAN, TECH, ECO, LANS, DEMOCRACY, AUTOCRACY, INFLATION, RISK (premium), DURABLE (of the current polity2 status), TRADE and FDIIN. When HDI was run, its components were not considered as independent variables.[4]

[4] Additional controls included in all of the regressions were latitude, HIV, dummies for missing values of fertility, trade, FDI inflows, inflation infant mortality and risk premium, the UNDP indicators for inequities in health, education and income (as fixed effects), and geographic regional dummies.

The second type of regressions were *growth regressions* in which the dependent variables was the rate of change instead of the level,

$$\Delta Y_{it}^{j} = \sum_{1\leq k\leq N} \beta_k Y_{it}^{k} + \sum_{1\leq k\leq M} \alpha_k Z_{it}^{k} + u_{it}^{j},\ j = 1, \dots, 5. \qquad (**)$$

The independent variables do not now exclude the level of the dependent variable, Y_{it}^{j}. The independent variables were again instrumented one by one as before.

The third type of regressions were *growth plus regressions*, in which to the *growth regressions* just described, the forward growth rate of the independent variable Y_{it}^{l} being instrumented was added as a dependent variable, adding the backward growth rate as an instrument.

$$\Delta Y_{it}^{j} = \sum_{1\leq k\leq N} \beta_k Y_{it}^{k} + \gamma_l \Delta Y_{it}^{l} + \sum_{1\leq k\leq M} \alpha_k Z_{it}^{k} + u_{it}^{j},\ 1 \leq j, l \leq 5, j \neq l. \qquad (***)$$

In effect this specification estimates the growth impact of above average improvements of independent variables, accounting for nonlinearities and for transitional effects.

All of the regressions were run using clustering errors for each country. This was the best specification in Mayer-Foulkes (2010a). For each regression, Hausman and Sargan specification tests were run on the instruments, using clustered errors in both cases. The Hausman test measures how significantly the instrument set is correlated with the residual of an OLS regression. Because the 1970-1985 averages level and growth rate and their multiplication by *t* are significant predictors of the dependent variables, the significance of the Hausman test mostly measures the degree to which endogeneity is important in the estimates. The Sargan test measures to what degree the instruments produce additional effects than through the independent variable they instrument. A significant result means that these variables have significant omitted impacts through other variables than the one instrumented, or nonlinearities, and that a better specification is needed, something that is not so surprising in growth regressions. For ease of inspection, the Tables for the Hausman and Sargan tests only show coefficients obtaining desirable results: p values respectively less than or greater than 0.1.

Because the data span the full range of developed and underdeveloped countries, growth regressions measure the *medium-term* impact of the independent variables, while the level estimates measure the *long-term* impacts. The reason is that the time involved in achieving development is between 30 and 200 years, while growth rates measure 5 year changes. Differences between developed and underdeveloped countries are indicated by differences in the *levels* of the main indicators, and a levels estimate tells which variables determine these differences, for instance the impact of

urbanization and trade on income, literacy, life expectancy and gross enrolment ratios.

Each set of regressions was run over the full sample and over the three subsamples provided by HDI and TECH terciles.

7. Dynamic Overview

Figure 6 showed that HDI is increasing across HDI levels. The figures in Appendix B show the rates of change for other variables, also across HDI levels defined by intervals of width 0.05 centered on the indicated values in the index scale from 0 to 1. The literacy, life expectancy and gross enrolment panels of Figure B.1 show systematic growth in these variables, although it is quite variable, particularly for life expectancy. On the other hand, per capita GDP has increased for HDI levels above 0.4 and decreased below that.

The fertility panel in Figure B.1 shows that overall fertility is higher at low HDI levels and lower at high HDI levels, consistently with the endogenous theory of the demographic transition (e.g. Galor and Mountford, 2008). At the same time fertility is declining through most HDI levels, with the highest declines at middle levels of HDI. The exception is at very high HDI levels and could be due to immigrant populations or other phenomena. This means that even at low HDI levels most countries are entering the decreasing fertility stage of the demographic transition. This is occurring at the same time as mortality rates are decreasing. Population growth rates overall are lower at higher levels of HDI. Consistently with this picture, dependency ratios are lower at higher levels of HDI, and are decreasing for HDI levels above 0.25, only increasing for HDI levels of 0.2. The mixed signs obtained for the fertility transition may involve cultural aspects that need to be considered.

Trade has increased for most HDI levels and tends to be higher for higher HDI levels. Urbanization increases with HDI levels and is increasing everywhere, particularly for HDI levels below 0.75. Turning to the panels of Figure B.2, both FDI inflows and relative technological levels have mostly increased, but very variably and not at all levels of HDI.

Ecological footprint per capita is positive mostly at higher HDI levels (negative values are due to missing data dummies). Per capita the footprint is decreasing. As for LANS (the log adjusted net savings polychoric measure), these are negative and decreasing for all HDI levels above 0.2, except that at HDI levels 0.8 and 0.85 some positive but decreasing savings are reported.

The autocracy variable presents positive values for all HDI levels below 0.85, and tends to be higher for lower levels of HDI. At the same time autocracy is decreasing almost everywhere where it is positive and almost exponentially. By contrast, democracy showed positive values throughout the HDI spectrum, with higher values for higher HDI levels, and increments of democracy through most of the spectrum up to HDI level 0.85.

Correspondingly Regime duration is decreasing for lower levels of HDI, where autocracy is more prevalent, and increasing for higher levels of HDI, were democracy is more prevalent. A simple linear regression of the autocracy and democracy phase diagrams shows autocracy disappearing and democracy converging to a level somewhat below 8.

Risk premium is positive across most of the HDI spectrum, and shows evidence of convergence: increasing where it is low and decreasing where it is high for HDI levels below 0.8. A calculation of the equilibrium levels of a simple convergence process shows them decreasing across HDI categories (last panel of Figures B.2).

8. Results

Our purpose is to discuss the impact of the several *aspects* of development on each other, which we group into Human Development, Population Growth, Urbanization and Technology, Sustainability, Institutions and Policy and Economic Integration.

These interrelations are discussed in two ways. First, it turns out that the Sargan and Hausman tests for the instrumentation contain very interesting information. Next we look at the significant coefficient tables.

8.1. Sargan and Hausman Tests

When significant, the Hausman test confirms the presence of endogeneity, or simultaneous determination, between the independent and dependent variables whose causal relation is being tested. If the result is not significant, this does not affect the validity of significant results for the instrumented variable, only their efficiency. When significant, the Sargan test implies that the instrument influences the dependent variable through other channels than the instrumented variable. In this case the independent variable is instrumented with its own levels and rates of growth during the period 1970-1985. Hence a significant Sargan test result implies that the independent variable we are studying has indirect impacts on the dependent variable, working through other channels. Hence a significant Sargan test implies that the coefficients obtained in the regression are measures of the direct impact that are biased by indirect impacts. However, so long as we know whether the Sargan test was insignificant or not, both results are interesting.

Systematically significant Hausman tests indicate that a variable interacts systematically in the determination of the other variables. Systematically insignificant Sargan tests indicate that a variable interacts indirectly in its impact on dependent variables. Each of these indicators in effect defines an influence ranking of some variables on other variables. Figure C.1 shows scatter plots of these results for the Levels and Growth regressions for the full

sample. The two rankings are remarkably consistent, and show which variables interact causally with more other variables. In this case, the variables most impacting the remaining variables in the long-term (Levels regressions) are, in approximate order: democracy; income; technology, gross enrolment ratio, urbanization and eco (a proxy for energy use); literacy and HDI; fertility; autocracy (there is no implied sign in the results); trade; FDI inflows; resource extraction and population.

By contrast, the variables most impacting the remaining variables in the medium-term (growth regressions) are, in approximate order: literacy; fertility and population; urbanization; autocracy; ECO (note energy use is determined endogenously with other variables to a larger extent than it impacts variables indirectly); HDI; GER; democracy; life expectancy; technology; trade; resource extraction; income and FDI.

The results are remarkably clear and say that the story of success is democracy, income and technology, together with enrolment, urbanization and energy use. By contrast the story of growth is literacy, fertility population and urbanization, impeded by autocracy, and by shortcomings in energy and human development.

How do these stories change across the different subsamples? Let's begin with the higher groups. Recall that there are 44 countries in each subsample, the lowest ones with 43. The story changes. Amongst the most crucial determinants of success or failure are literacy, autocracy, technology and fertility. Amongst the most crucial determinants of growth are literacy, fertility, population and democracy; urbanization, enrolment, and FDI inputs.

Turning to the middle groups, success is related to (low) fertility, income, HDI, literacy, technology, FDI. Growth in addition involves population (scale effects?), urbanization, democracy.

In the lower groups, enrolment, income, life expectancy, technology, trade, population and energy have crept up relatively by comparison. In the case of growth population, enrolment, urbanization, literacy, autocracy, human development and energy use are the most important, then technology, income, life expectancy and trade.

8.2. Significant Coefficients

We now analyze the tables presenting the significant coefficients. The results represent interaction matrices whose elements are the impact coefficients of independent variables (arranged by rows) on the dependent variables (displayed by columns). The borders of these interaction matrices between different aspects of development use thicker lines.

Results for the three types of regressions are presented together, so each of these matrices cells has three rows, the first for the *level regressions*, the second for the *growth regressions*, and the third for the *growth plus*

regressions. Recall each coefficient comes from a separate regression in which only the specific independent variable is instrumented. The coefficient therefore measures the correlation of the level of this variable with the causal determinants respectively of the level or growth of the dependent variable, and of the contemporary growth of this variable with the growth of the dependent variable.[5]

We next give a bird's eye view of the causal interactions of variables representing each aspect of development in turn. We discuss the human development components last.

The result tables have been colored for easier reading. Significant coefficients passing the Sargan test for which more of one good leads to more of another good (or a bad to a bad) are colored in *Green*, and the others are colored *Lilac*. To do this, I have considered GER, logGDP, LIFE, LITERACY, URBAN, TECHrel, DEMOCRACY, TRADE, FDIIN, DURABLE as goods and ECO, LANS, AUTOCRACY, FERT, logPOP, DEPEND, INFLATION, INFMORT, RISK as bads. In fact DURABLE is a good in the case of democracy and a bad in the case of AUTOCRACY. In the case of coefficient related to fertility and population green is therefore consistent with the demographic transition and Lilac with a Malthusian tendency. Tables A contain the individual coefficient results for all three types of regressions. When they apply, conditional convergence coefficients are marked in yellow and conditional divergence in red. Tables AS contain a summary of Tables A, in which each cell represents a category of indicators. The number reported is the number of Green minus the number of Lilac coefficients for the impact of each category of indicators on each other category of indicators, a positive result indicated in Green and a negative one in Lilac (convergence coefficients excluded). The categories are human development (the four indicators used by UNDO plus infant mortality), demographic transition (logPOP, FERT and DEPENDENCY), *urbtech* (urbanization and technology), sustainability (ECO and LANS), democracy (including decreases in autocracy), administration (low premium risk, low inflation and institutional durability) and integration (trade and FDI).

Table AS.1 shows, by adding significant signs for the three types of regressions, that on the whole human development is supported by and consistent with human development itself, the demographic transition,

[5] While instrumented regressions are congruent with causal analysis, a word of caution is in order. What happens in these estimates is that a space of causes is assigned according to correlation strengths. In so far as the independent variables proxies for the set of causal factors, and the instruments span causally significant aspects of the independent variables, when a variable obtains a significant coefficient this means that it is significantly correlated with the causes, maybe more so than other variables. While this may seem to be a weak causality statement, that is precisely what is meant by statements such as "trade is an ultimate cause of economic growth". After all, "trade" refers to a general category of actions. What the statement means is that such processes as learning, technological change, competition, and so on are especially connected with trade, or that "trade is significantly correlated with causal factors of economic growth".

democracy, and good administration. As a whole, urbtech and integration yield neutral results, while sustainability runs counter to human development.

Turning to the demographic transition, this is promoted by urbtech and integration. However sustainability runs counter to the demographic transition. Table A.FULL.1 shows that the lilac entry under demographic transition is due to population increases yielding fertility decreases, which is not in fact inconsistent with the demographic transition, and to decreases in fertility yielding increases in the population, which can occur in the early stages of the transition.

Urbanization and technology are being promoted by human development, urbtech itself, and administration. Sustainability is running counter to urbtech, as well as the demographic transition. This could happen for example if the demographic transition occurs in rural areas.

Interestingly, sustainability is promoted by human development, the demographic transition, urbtech, sustainability and administration, but is compromised by integration and neutral to democracy.

Democracy on the other hand is promoted by the demographic transition, urbtech, and democracy itself. However, it has negative feedbacks with administration and sustainability.

Economic integration is promoted by human development, the demographic transition, urbtech and integration itself. However it is slowed by administration.

Another way of making this summary would be to say that overall, all of the selected goods have net positive feedbacks on each other, except for the interaction of the demographic transition with itself, which may be an artifact of natural lags in this process, the slowing of urbtech by the demographic transition, which may be a not undesirable effect of rural transition, because of the negative impacts of sustainability (read as an energy deficit) on human development, the demographic transition, urbtech and democracy, retarding effects of administration on democracy and integration, and a negative effect of integration on sustainability.

The picture changes considerably when we look at the subsamples, because now we are looking less at contrasts across a large range of countries and instead looking at differences between more similar sets of countries. One result is that there is a considerable variability of results across subsamples. The most salient differences between the results in Table AS.2 and those already discussed in Table AS.1 are the following.

Urbtech is not longer neutral to human development, having net negative impacts except for intermediate technological levels. The negative net impacts of sustainability restrict to low technological levels, and the impacts of democracy, administration and integration are variable across subsamples.

Human development and urbtech can now run counter to the demographic transition, but democracy can favor it.

Democracy can run against urbtech for more and administration for less developed countries. For countries with similar human development levels, integration can foster urbtech.

For countries with similar human development or technological levels (except the highest technological level) high human development leads to less democracy, consistently with the idea that deficits in human development cause democracy.

Sustainability is slowed by urbanization for countries with similar technological levels, or similar intermediate or low human development levels, perhaps due to energy consumption under conditions of congestion.

Integration is slowed by urbanization for countries with similar technological levels, perhaps because more urbanized countries have also traditionally been less integrated. Democracy is also slowing integration for some subsamples.

8.3. Summary of results

We have shown three types of results that each contribute to establish what the main features of the current dynamics of human development are. The first was a descriptive study of HDI dynamics (Figures 5 to 7) and a dynamic overview of the average rates of change of the key variables by HDI categories (Figures B). The second was the analysis of Hausman and Sargan test results (Figures C). The third was the analysis of the regression coefficients for the levels, growth and growth plus causal regressions (Tables A). According to these results the main features of the current dynamics of human development are described in Inset 1.

9. Sustainability and Development

In this section we specifically investigate the causal relation from human development to sustainability. We first conduct a descriptive analysis and then run causal level and growth regressions for the impact of the same causal factors on sustainability indicators.

The indicators we use fall into three categories. The first are essentially *energy use indicators*: fossil fuels per capita, energy use per capita, electricity use per capita, alternative energy per capita and CO_2 emissions per capita. These are consumption indicators. The average of these indicators by HDI categories 0.05 wide, rescaled from 0 to 1, is shown in Figure 8.1. It is noteworthy that energy use is *exponential* in HDI levels, see Figure 8.2. There is an 85.5% correlation between HDI and log fossil energy use per capita (with only 53.6% without the log).

The second category is essentially *ecological indicators*: ecological footprint per capita, bio capacity per capita, ecological balance and CO_2

intensity per capita. Biocapacity and ecological balance take into account the size of the ecological resources of the countries involved, while CO_2 intensity measures how much CO_2 is used per unit of energy use. The average of these indicators by HDI categories, also rescaled from 0 to 1, is shown in Figure 8.3.

INSET 1. MAIN CURRENT DYNAMIC FEATURES OF HUMAN DEVELOPMENT

I. Human development is characterized by a series of broadly advancing transitions:
   a. The demographic transition, which is one of its main features. Even though population growth still continues, especially at low HDI levels, the dependency ratio and fertility transitions are advancing.
   b. Human development proper: literacy, enrolment and life expectancy, infant mortality.
   c. The urbanization transition.

II. There is an institutional transition: democracy is systematically increasing while autocracy is systematically decreasing. Even risk premium decreases with HDI.

III. The HDI distribution is broadly twin peaked, in dynamics that correspond with the demographic transition, with higher fertility in the lower peak than in the higher peak. HDI improvement dynamics display substantial qualitative differences across HDI and technological levels. These two stratifications are substantially different in turn.

IV. The income transition was not automatic:
   a. Income per capita increased for HDI levels above 0.4 (without therefore converging), but decreased for levels below this value (implying divergence).
   b. Trade was generally higher for countries with higher HDI and tended to increase.
   c. Relative technology levels did not display a clear pattern of improvement across HDI levels.

V. The sustainability challenge.
   a. The worst per capita sustainability problems are for high and very low HDI levels.
   b. The demographic transition, as well as human development, urbanization, technological change, and good administration broadly promote sustainability.
   c. However, low levels of energy consumption slows human development, the demographic transition, urbanization and the absorption of technology.

VI. The dynamics of HDI are complex, circumstantial and nonlinear. For each of these main currents of development there are many countercurrents. Examples:
   a. Some HDI components can become substitutes, such as life expectancy and literacy (see top left hand corner of Table A.Full.1 Levels).

b. Technological change, trade, FDI, urbanization and sustainability sometimes run with and sometimes against human development and the demographic transition.
c. Although human development usually runs with the demographic transition, sometimes it does not.

Biocapacity and ecological balance clearly include geographical attributes. For example the comparably shaped graph for Country Area is shown in Figure 8.4. This Figure also shows latitude and landlocked. The first is strongly correlated with development (and also energy use for winter heating) and the second with underdevelopment. CO_2 intensity per capita clearly shows increasing but inefficient use of energy for middle levels of HDI. On the other hand ecological footprint only begins to matter at the 0.55 HDI category.

The second category is essentially *ecological indicators*: ecological footprint per capita, bio capacity per capita, ecological balance and CO_2 intensity per capita. Biocapacity and ecological balance take into account the size of the ecological resources of the countries involved, while CO_2 intensity measures how much CO_2 is used per unit of energy use. The average of these indicators by HDI categories, again rescaled from 0 to 1, is shown in Figure 8.3. Biocapacity and ecological balance clearly include geographical attributes. For example the comparably shaped graph for Country Area is shown in Figure 8.4. This Figure also shows latitude and landlocked. The first is strongly correlated with development (and also energy use for winter heating) and the second with underdevelopment. CO_2 intensity per capita clearly shows increasing but inefficient use of energy for middle levels of HDI. On the other hand ecological footprint only begins to matter at the 0.55 HDI category.

The third category of sustainability indicators are *dissaving indicators* measuring the unreplenished use of natural resources: energy dissavings per capita, mineral dissavings per capita and forest dissavings per capita, as well as CO_2 dissavings per capita. This category is more related to production. Figure 8.5 shows the averages of these indicators by HDI categories, again rescaled from 0 to 1. The shapes clearly represent those countries with energy, mineral and forest production. The CO_2 dissaving data does not coincide with the CO_2 emissions data (both are per capita in this case).

We now turn to the regressions. The level regressions are exactly like (*), except that the principal factor indicators ECO and LANS were omitted because they were at least somewhat collinear with the dependent variables, which were the logarithms of the 13 sustainability indicators mentioned above, in per capita form. The growth regressions were exactly like (**), ECO and LANS again omitted, with the convergence term included instead. Both sets of regressions were run over the full sample and over the three subsamples provided by HDI and TECH terciles. For some of the subsamples there were insufficient observations for the clustering to be possible.

Overall the convergence term was negative, except for Ecological Balance for the full sample, CO_2 dissaving for the HDI2 and TECH3 subsamples, energy dissaving for the HDI2, TECH1 and TECH3 subsamples, mineral dissaving for the HDI1 and TECH1 subsamples, biocapacity for the HDI1, HDI3 and TECH1 subsamples, and energy use and ecological balance for the TECH3 subsample.

We report the level and growth regressions in the same tables as before, only reporting those significant coefficients for which indirect impacts of the instruments were less than 10% significant, as determined by the Sargan test. Tables B.1 and B.2 show the results for the per capita energy use indicators: energy use, CO_2 emissions, alternative energy, fossil fuels, electricity use and CO_2 intensity. Following the same criteria as before, consistently green coefficients are obtained for the impact of the human development indicators LIFE, LITERACY, GER, logGDP, INFMORT (less) and logPOP (less) on CO2 Emissions (less) and alternative energy (more). The opposite is true for electricity use, including FERTILITY and TECH. In addition, improvements in the institutional and administrative indicators INFLATION, RISK and DURABLE are almost consistently green on all of the energy use indicators. Technology levels are also almost consistently green. By contrast, Trade and FDI and democracy are ambiguous, while decreases in autocracy are almost consistently "red". This analysis is also summarized in Figure 9.1.

Our main results are those for energy use indicators, because these are the ones most reliably reflecting sustainability. Summarizing, while significant coefficients are relatively sparse, human development relies more heavily on electricity than on CO_2 emissions, life expectancy is green, technology is almost consistently green, and some institutional and administrative improvements yield significant green coefficients. (See Inset 1).

Universal access to electricity is one of the most important goals of development, and a necessary ingredient for economic growth and human development. Electricity provides an indispensable input both for households and for production (Crousillat, Hamilton and Antmann, 2010). In arguing for the Green New Deal, AtKisson (2009) also emphasizes the importance of electricity supply for human development. Thus the contrasting results obtained for electricity and CO_2 emissions are very interesting and point out that appropriate policies for sustainable human develop should distinguish between different energy forms and energy uses. Electricity requires a fixed energy source that can be improved and made greener and more renewable with time, and through digital communication help to substitute energy used for transportation, which tends to be less efficient and more CO_2 intensive.

Figure 9.2 shows a similar analysis for the ecological sustainability indicators, full results in Table B.2. The only notable green factors are gross enrolment ratio and a smaller population. Notably red are less fertility, autocracy or urbanization. Most other indicators are ambiguous. Figure 9.3 shows the analysis for the dissaving sustainability indicators, full results in

Table B.3. These indicators probably reflect energy production more than consumption. Correspondingly, notably green influences are given by trade, urbanization, and several institutional indicators. Notably red indicators are population, lower dependency ratios and technology. Most other indicators are ambiguous.

10. Discussion

Human development follows a political, institutional and economic process. A review of its causal factors shows that market rationality only applies to part of this system. It follows that human development can benefit from the application of public policies. Our summary of the main current dynamic features of human development implies the main policy suggestions (Inset 2).

The importance of different variables on long- and medium- term human development varies across the development process. Grouping countries according to their HDI or technology levels produces quite different rankings for the causal factors we studied. It follows that HDI policies supporting human capital investment need to be tailored to local conditions, human development and technological levels, and need to use specific studies and evaluations.

The demographic transition, education, health, and access to a higher income are the main processes of human development. These are all promoted by human capital returns, which themselves depend on technological knowhow. Galor and Mountford (2008) have shown that trade can localize these returns to some countries and not others through specialization in human capital. The same may occur through innovation externalities gained through FDI and trade that can favor advanced countries, generating development for some and poverty for others (Mayer-Foulkes, 2009). A series of other mechanisms systematically slowing technology transfer may exist that are not well understood. After all lagging technological levels is *the* fundamental characteristic of underdevelopment. One example that does not much appear in the theory is the tendency of markets to concentrate into huge corporations that wield enormous power and concentrate economic activity and technological knowhow.

Raising human capital returns by strengthening technology transfer as directly as possible to the poor and to poor regions can be a fundamental tool for development, addressing the fundamental problem of development, eliminating the two essential determinants of divergence by also raising the incentives for human capital accumulation and promoting the demographic transition. One possibility could be micro technology transfer together with microcredit, using web pages designed for the purpose.

Innovation is the Achilles heel of neoclassical economics, since the dynamics of productivity are run by incentives for market power. A world with NGO or other support for technology transfer is *more* neoclassical, not less.

Strengthening technology transfer is a necessary complement of the Green New Deal, the set of policies for jumpstarting the implementation of renewable energy described above (AtKisson, 2009). This is because over a longer term horizon sustainability is only possible if the incentives are in place to achieve the demographic transition and human development. These require sufficiently high returns to human capital. Energy availability will cheapen but not necessarily ensure the implementation of new technologies, whose transfer must also be supported. If instead returns to human capital continue to be low, cheap energy might contribute to a continued population explosion. Poverty will only end with the demographic transition.

At the other end of the development spectrum, high human development levels are currently unsustainable. This poses a fundamental technological challenge that only the advanced countries can solve.

The failure of the neoclassical paradigm to account for and support technology transfer explains its failure to end income divergence by promoting the demographic transition and the absorption of technological knowhow. Amazingly, the neoclassical policy paradigm also fails to promote democracy. Believing markets will take care of economics, huge concentration of market power is tolerated that runs against democracy throughout the world (for the impact in the US see Kahn & Minnich, 2005). But when markets fails to supply essential goods, such as education, health, infrastructure, technological change, and so on, democracy is the recourse of last resort, making appropriate public action possible. This is how democracy promotes human development: it supports the incentives and accountability for producing the corresponding public goods.

The results show that there is an institutional transition occurring together with human development, in which democracy is systematically increasing, while autocracy is systematically decreasing. As cited above, Welzel and Inglehart (2001) and Welzel, Inglehart and Klingemann (2002) show that human development itself, consisting of socioeconomic development, cultural change and democratization, broadening human choice (consistently with Sen) is *causing* the deepening of democratic values and institutions. It follows that democracy, broadly understood as political and economic, is an integral part of human development that must be supported by human development policy.

There may also be a place for helping to solve public resource allocation conflicts that may exist, for example between literacy and health or between broad policy conceptions, such as technological change versus human development.

This does not mean that there must be state intervention, but rather that ways have to be found to support the empowerment of diverse actors in society and to facilitate the transitions from autocracy to democracy, which involve significant risks and significant learning. The transition between autocracy and democracy is not simple. As Figure 4 shows, there is an

inverted U relation between the HDI and Polity2 that may be due to a lower degree of governance in between the two types of regime. An example is given by Mexico, with close to 12 years of a deadlocked congress since the PRI left power after 70 years, and a relatively low involvement of the population in democratic life. In themselves, democratic economics and improved governance can be considered as development policies (Mayer-Foulkes, 2010c).

The history of ideological conflict through the 20th Century is such that phrases like "promote democracy" or "promote public goods" are ideologically charged in terms of "right" or "left," as if opposing poles along a left to right continuum meant anything. Instead, what mean something are the values that define human development: capabilities and freedom; the objective difference between public and private goods; and a balance between them that depends on circumstance and predilection (Figure 10).

The estimates and other work show that increased human development is consistent with sustainability up to a level of HDI of about 0.7, although not with high incomes per capita. Also, some of the worst per capita sustainability problems occur at very low HDI levels. Sustainability offers a two-fold challenge, first, to develop sustainable technologies, and second, to develop appropriate regulation. The developed world can evidently not hope to delegate the technological challenge to the less developed world. Also, it cannot hope to manipulate prices to pay for a higher ecological footprint.

Even with appropriate technologies (some of which requires technological transfer to the very poor), there are problems which will require regulation. The point here is that global regulation needs to be supported by global governance, that is required for ever more reasons.[6]

INSET 2. MAIN POLICY IMPLICATIONS FOR HUMAN DEVELOPMENT AND SUSTAINABILITY

I. Facilitating technology transfer is key for raising the returns to human capital and promoting the demographic transition, human development, and convergent development in general.

[6] For example, preventing Non-Communicable Chronic Diseases, which threaten to cost more than retirement costs, requires global policies for controlling the nutrition transition to junk food, harmful advertising of this consumption, and the inappropriate use of alcohol and tobacco (Mayer-Foulkes, 2011). Choosing appropriate and sustainable forms of transportation, such as urban transit over automobiles, also requires controlling large vested interests. There is also a strong case for harmonizing Trans National Corporation (TNC) taxes, 1) to stop subsidizing international production at the expense of local production, 2) to rebalance the public and private sectors, 3) to provide FDI hosts with funding for development proportional to value added at FDI's home countries, 4) to promote global public goods and global governance (Mayer-Foulkes, 2009). Another point worth mentioning is that globalization has strongly increased the concentration of production. The world's top 100 non-financial TNCs produced 14.1% of 2008 output. Yet industrial concentration is and has traditionally been even higher in the US, 40% for the 200 largest manufacturing companies from 1992 to 2002 (Mayer-Foulkes, 2010c). The risk is therefore that global economic concentration could continue to rise towards US levels, posing even greater challenges for TNC regulation.

II. Sustainability. Human development requires renewable energy sources, particularly electricity. The Green New Deal offers a proposal for achieving this that simultaneously promotes sustainability and development.

III. Transitions towards political and economic democracy, equal rights, and the provision of public goods, must be supported in tandem with market institutions. Democracy is an essential ingredient for creating a balanced economic system promoting human development, and also a quintessential expression of human development.

IV. Human development policies should continue to promote the main transitions by providing the investments that markets do not provide, such as

   a. Human capital investment, mainly early child development, education and health.
   b. Urbanization, transportation and communication.

V. HDI policies need to be tailored to local conditions, and to local human development and technological levels. They also need to be permanently evaluated and reformulated.

VI. The global governance challenge. Global interaction and global markets require global governance. Promoting technological change and governance in less developed countries and bringing the poorest out of poverty provides institutional support for additionally needed global policies.

VII. These policies also support the income transition.

Conclusions

The modern theory of economic growth recognizes two sources of divergence in economic and human development, differences in fertility and differences in technological absorption. The availability of technology as well as incentives to create it, raise human capital returns, and in turn this raises the incentives to reduce fertility and invest in human capital. All other determinants of economic growth are levels determinants, including institutions. The new UNDP data base (Gidwitz et al, 2010) on human development indicators allows a descriptive and causal examination of the medium and long-term dynamics of human development. The results confirm that, while the dynamics of HDI are complex, circumstantial and nonlinear, broadly speaking the main human development transitions are advancing: the demographic transition, and human development proper: literacy, enrolment and life expectancy, infant mortality; urbanization. Finally, there is an institutional transition towards democracy and away from autocracy. The income transition, though, is much less clear.

The analysis of sustainability indicators shows that the demographic transition and low and medium levels of human development are broadly consistent with sustainability, but that human development particularly requires electricity. On the other hand, high levels of human development are currently unsustainable. Viable, renewable energy sources are indispensable. The Green New Deal offers a proposal for achieving low enough renewable energy prices, consistently with a development program for the world's poor. However, sustainability is only fully possible if the demographic transition and human development succeed.

The results therefore show that technology transfer is the key to sustainable human development. Up to now, economic policies have hoped that technology transfer would be the result of enough human capital investment, institutional change, economic integration, and so on. It is time to address the problem directly, and to set technology transfer as an objective in itself. It is imperative to recognize that a technology transfer deficit prevails under the market system. Facilitating technology transfer, as directly to the poor as possible, will make the economy *more* neoclassical, not less.

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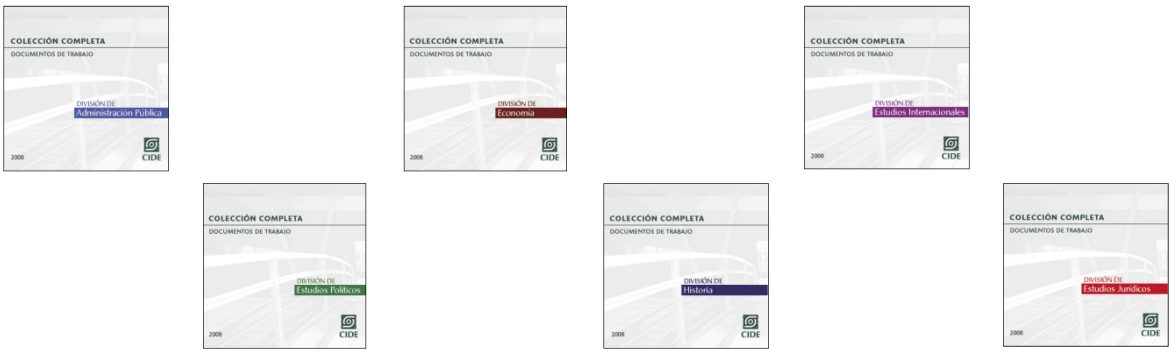

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