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A CONTRIBUTION TO THE "PURCHASING POWER PARITY VS. MARKET EXCHANGE RATES FOR USE IN LONG-TERM SCENARIOS" DISCUSSION

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ABSTRACT

Market Exchange Rates (MER) balance he demand and supply for international currencies, while Purchasing Power Parity (PPP) exchange rates capture the differences between the cost of a given bundle of goods and services in different countries. When undertaking multi-country analysis of environmental issues (such as climate change) that includes different currencies, a decision has to be made as to whether to use PPP or MER in the analytical framework. The distinction between them is particularly germane in inter-temporal studies that postulate future scenarios. PPPs are generally favoured for their closer link to welfare, but MERS are necessarily the basis of international trade, so it is difficult to choose between them. Some authors have noted some empirical regularity between them and have sought to exploit this to avoid choosing between PPP and MER. In this paper, it is shown that such *ad hoc* adjustments are not necessary when structural changes are accounted for.

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A CONTRIBUTION TO THE "PURCHASING POWER PARITY VS. MARKET EXCHANGE RATES FOR USE IN LONG-TERM SCENARIOS" DISCUSSION

1. Introduction

The development of very long-term analysis looking more than 50 years into the future is a fairly recent addition to economics-based public policy discourse. In the past, the analytical timeframe was limited to roughly 25 years for policy issues that had long horizons. For example, interest in the sustainability of budget deficits and public pension schemes led to the study of roughly 25-year extrapolations of those programs. This often required building a baseline in which the outcome of current policies would be projected over 25 years to study their impacts. Those baselines and policy responses could then be used to advise policy-makers on the need for, and effectiveness of, various measures.

Continued economic growth and technological development, however, have now made time horizons of 25 years seem rather short-sighted for some issues. A longer-term perspective is needed. In particular, the ability of society to transform the environment has become so potent that the human impact on the planet is simply a matter of choice, not limitations in human capabilities. Some scientists have been willing to venture that the impact of human choices is already on the scale of one of the five mass extinctions found in the fossil record. That is, human transformation of the natural environment is similar to events that defined the palaeontological boundaries of major periods in the development of life on the planet (see Thomas, J. A., *et al*., 2004; Gibbs, 2001). Given this level of potential repercussions from human activity, it behoves policy-makers to take a very long-term view in their decisions impacting the environment. A more focused example of the need for long-term analysis comes from the fact that the half-life of carbon dioxide in the atmosphere is approximately 125 years. That means that current emissions will still significantly impact on the environment of the 22nd century. Such impacts must be accounted for in the policy-making process when decisions leading to substantial emissions are contemplated.

Thus, there is a need to look out beyond the short period of time that is within the normal purview of existing analytical approaches. Those approaches can be broadly characterised as either undertaking introspective *qualitative* analysis, or an explicitly *quantitative* analysis. Introspective analysis typically involves an intuitive consideration of potential impacts and how policy might avert adverse outcomes. Introspection works well for gaining insights into an issue, but has difficulty in specifying the quantitative steps that policy-makers should take. Generally, such analysis is limited to working with fairly simple conceptual/theoretical models, and thus lacks the capacity to account for the wide range of issues that a policy decision may affect.

Quantitative analysis, for its part, would be seen as trying to push analytical tools (such as numerical models) into the realm of "scientific guessing" or "guesstimation". To understand the limited power of models, imagine using one at the beginning of the 20th century to provide results that looked out to the beginning of the 21st century. Any such analysis would certainly have turned out to be wrong. This is, however, not the main issue in deciding to undertake a model-based analysis. The numerical accuracy of the results is only part of the story; more important are the lessons learned from a broadly specified set of inter-relationships that are rigorously integrated (i.e. by a computer in a numerical model). The accuracy of the results is then relevant mainly to how those lessons are presented and used in public-policy development.

Moreover, the lack of accuracy in projections implies that policies need to be constantly revised to ensure that the objective is still relevant after new information becomes available. A policy that is optimal today, given all available information, might not be optimal, (or even relevant), a few years hence. If the scientific analysis underpinning the policy is unbiased, then it is just as likely that things will turn out worse than expected as that things will turn out better. For example, the initial policy program that was put into place to deal with the loss of atmospheric ozone had to be accelerated when it was subsequently observed that ozone loss was occurring more rapidly than expected.

Since the numerical accuracy of the results are not of primary importance, and there is a need to look out over a very long time horizon, the main use of model projections (and analyses) is to provide broad-brushed images of the policy environment. The main focus of model development in this context is to make those images as rigorous as possible – this will increase the comfort level that something useful is being learned. The level of rigour will itself be contingent upon the use of the best theories and data available. In other words, model-based analyses over the very long term need to come with the assurance that there are not obvious short-comings in the underlying specification.

Recent attempts to provide very long-term analysis include the IPCC Special Report on Emissions Scenarios (IPCC, 2000), the Millennium Ecosystem Assessment (2005), and the United Nations Environment Program GEO study (UNEP, 2002). These have looked at very long term horizons that extend up to 100 years – thus they have pushed the limits of available quantitative tools and techniques.

2. The role of PPPs and MERs in long-term studies

Some of those long-term studies have drawn critical review. When measuring income (e.g. GDP), using purchasing power parities (PPP) is more appropriate for looking at long-term issues in developing economies than is income measured using market exchange rates (MER). Essentially, the distinction between PPP and MER is one of how to measure the value of incomes in particular countries. As travellers to developing countries know, locally produced goods there are generally cheaper than they are in a developed country. This means that a USD10,000 income in a developing country will purchase considerably more than the same income would purchase in a developed country. A PPP-based measure of income adjusts for this phenomenon by revising upward the measured income level. An MER-based measure of income does not make that adjustment, and thus underestimates the well-being of individuals in a developing country.

Castles and Henderson (2004) point out that this issue is relevant to some of the work of the Intergovernmental Panel of Climate Change (IPCC). Broadly, growth rates of developing countries measured over a given period are likely to differ according to the measure used (PPP or MER). In a projection exercise, if convergence in income levels is postulated to occur by a certain date (as it is in some of the above-mentioned projections), the difference between the two measures will impact on the growth rates. That is, since MER is starting from a lower level of measured income, to achieve convergence by a certain date, the MER-measure of income will have to grow more quickly.

The problem with assuming this higher growth is that emissions may be overstated if they are linked directly to growth in GDP.[1] This issue subsequently led to a literature that examines the impacts of using the two measures of national income (e.g. Nordhaus, 2005; Manne and Richels, 2003; Holtsmark and Alfsen, 2004; McKibbin, Stegman and Pearce, 2004)

Since many studies that undertake long-term projections contain an economic core that specifies GDP growth as a driving factor for environmental consequences, attention needs to be paid to the distinction between PPP- and MER-based measures of income. This is, therefore, one of those areas that long-term global analysis needs to consider carefully.

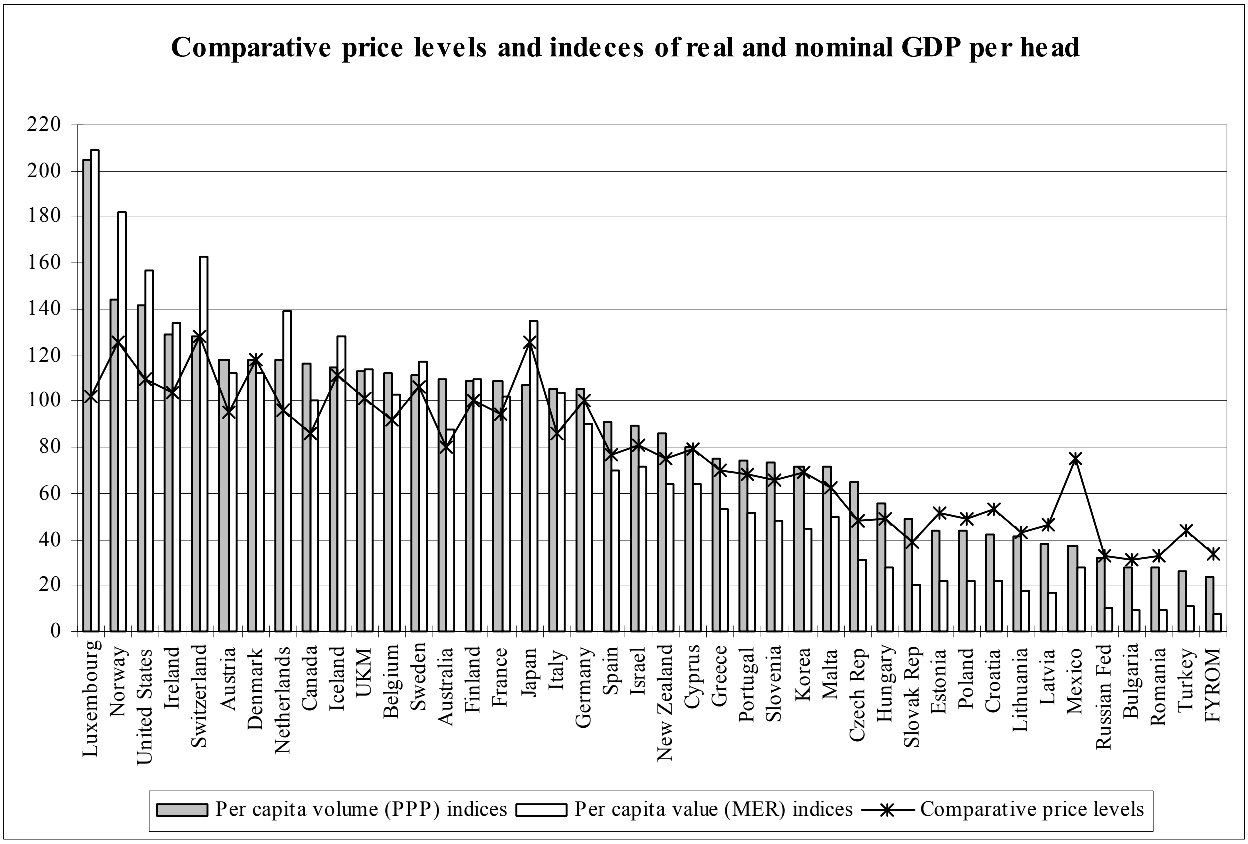
3. Why do PPP- and MER-based measures of income differ?

Figure 1 shows relative GDP per capita across a number of countries – based both on an MER measure, and a corresponding PPP measure.[2] In each case, they are compared to the average income level of the group; i.e. a country whose MER-based measure of income is equal to 100 is exactly on the average for the group. There is also a line that compares PPP and MER incomes – so that when the line is at 100 on the vertical axis, PPP and MER measures of income are equal. The countries are ordered by decreasing PPP-based relative per capita GDP.

1. Unless there is an offsetting change assumed in the emission-intensity of GDP growth when switching between PPP and MER measures of GDP.

2 The data for Luxemburg need to be considered carefully, since a “frontier worker” phenomenon implies that up to a quarter of its GDP is produced by people not residing in that country (and thus not counted in population totals).

Figure 1. **Purchasing Power Parities, 2002 Benchmark Year**



Source: OECD (2004).

What the Figure shows is that there seems to be some regularity between how poor a country is and how much the PPP-based measure of income exceeds its MER equivalent: to the right of the Figure (where overall incomes are lowest), PPP-measured incomes are significantly higher than their MER counterparts. An immediate question that arises is what may cause that to occur, or why is it that development necessarily implies an increase in the purchasing power of an income relative to the international value of that income? An implication of Figure 1 is that the process of development *in-and-of-itself* engages economic changes that lead to a closing, and even a reversing, of the gap between PPP and MER.

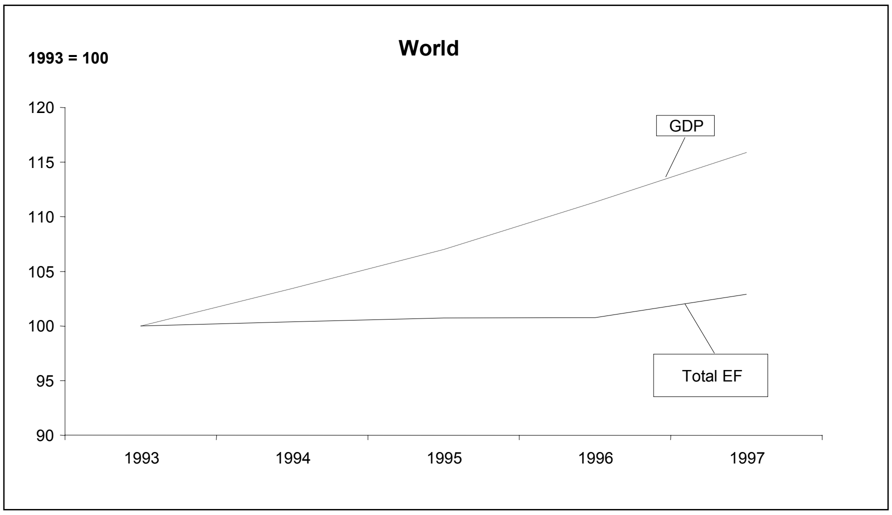
Part of the answer to the question of why development leads to a changing PPP/MER gap is found in the relationship between goods that are traded in international markets versus goods that are not traded internationally. Because developing countries produce local goods and services that are not traded, the price of those goods will more closely reflect local incomes. As development proceeds, those local goods will become more valuable and their price relative to internationally-trade goods will rise. This occurs because the price of internationally traded goods is fixed in the “world” market, so increasing incomes impact disproportionately on the price of locally produced goods and services. By implication, PPP will be impacted more than MER because the price of local goods compared to international goods *defines* the difference between PPP and MER. A more detailed discussion of the technical issues involved is given in Bagnoli, Chateau and Sahin (2006).

4. Sectorally differentiated growth in a model

Because distinctions between traded and non-traded goods matter, distinguishing between economic sectors is a prerequisite for observing differences in PPP versus MER measures of income. In turn, understanding changes in relative prices between traded and non-traded goods and services require use of a general equilibrium model if these are to be reproduced endogenously. Models that are primarily engineering-based energy models – i.e. process-based – that have only a rudimentary accounting of the full economy, will fail to capture this effect.

Models that are sectorally detailed are also better equipped to capture the relationship between specific economic sectors, including their environmental impacts. For example, the phenomenon of "de-coupling" between economic growth and both environmental impacts and material inputs is more easily represented with greater sectoral detail. To get a perspective on the recent de-coupling between aggregate economic activity and the impact on the environment, consider Figure 2. The two lines representing economic activity (GDP) and environmental impact (Total Ecological Footprint, EF) diverge throughout the 1990s. The concept EF (developed by the World Wildlife Fund, WWF) is used as a proxy for aggregate environmental impact, since it represents the biologically productive area needed to: produce the food and wood people consume; give room for infrastructure; and absorb the CO_2 emitted from burning fossil fuels. For more detail on EF, see OECD (2002).

Figure 2. **Total ecological footprint**



Source : WWF Living Planet Report 2000

There is a clear difference between the two trends that are illustrated. A sectorally-detailed model help explains this difference: by having sectors that impact on the EF grow at different rates from sectors that do not. One way such models achieve this distinction is by varying rates of productivity growth in particular economic sectors.

For a numerical illustration of historical differences in sectoral productivity, consider changes in output per hour worked across different industries. As Table 1 shows for a number of countries, there are significant differences across industries – so the composition of growth is obviously an important part of the environmental impact that growth will have.

The primary source of these differences in sectoral productivity is technological change – this change occurs more rapidly in some business sectors than it does in others. All advances in knowledge that are relevant to commerce necessarily manifest themselves as labour productivity growth; i.e. they increase the value of what is produced for each hour of work. That is, when using the measure of output per hour worked, technological change will be observed, irrespective of whether it occurs through improvements in human capital or in physical equipment.

This uneven change (leading to uneven growth) across sectors is the source of both: (i) the divergence between environmental impacts and GDP growth; and (ii) the changing relationship between PPP and MER measures of income. To see the impact on PPP and MER measures of income, a simulation was undertaken with the ENV-Linkages model that projects sectoral trends similar to Table 1 out to 2030 for all economies. To make up for a lack of high quality data for some regions, and to simplify the interpretation of the results, an aggregation was imposed on regional productivity data. Table 2 illustrates the specific sectoral trends that were used in this process.

Table 1. **OECD Sectoral labour productivity growth (1980-2001)**

	Agric.	Forest., Fishing	Energy †	Non-durable Manufact.	Durable Manufact.	Trade, Transp.	Services
Australia	3.2%	2.9%	4.9%	1.9%	3.2%	1.2%	0.3%
Austria	5.2%	5.1%	3.9%	4.1%	8.4%	2.8%	3.0%
Belgium	4.2%	5.9%	4.2%	2.8%	6.1%	1.3%	1.5%
Canada	2.1%	-1.2%	1.2%	1.2%	4.0%	-2.3%	1.1%
Czech Rep.*	10.3%	10.5%	0.8%	11.3%	4.8%	12.4%	-2.7%
Denmark	7.3%	1.0%	5.8%	1.6%	3.5%	0.0%	3.8%
Finland	2.1%	4.1%	5.1%	4.5%	6.7%	2.8%	2.6%
France	5.9%	-1.3%	2.3%	0.8%	5.8%	3.0%	1.5%
Germany	5.8%	2.8%	2.9%	1.3%	2.9%	3.0%	1.9%
Greece	1.7%	2.8%	3.7%	3.1%	1.1%	1.3%	-2.1%
Hungary*	5.6%	6.0%	-0.8%	-1.0%	2.6%	4.6%	-0.4%
Ireland	4.2%	3.3%	7.2%	6.3%	15.5%	2.7%	1.0%
Italy	5.0%	5.9%	1.2%	2.3%	4.6%	1.6%	0.2%
Japan	3.0%	1.4%	3.0%	0.0%	8.8%	3.0%	2.7%
Korea	7.1%	4.1%	9.0%	4.2%	15.1%	3.2%	0.8%
Luxembourg	5.4%	6.5%	4.4%	-0.4%	5.6%	3.9%	0.0%
Mexico*	1.9%	1.9%	2.6%	1.7%	1.7%	1.0%	-0.2%
Netherlands	3.4%	1.6%	0.9%	3.7%	4.4%	2.7%	2.4%
New Zealand	5.1%	5.0%	2.2%	1.4%	1.4%	4.2%	2.4%
Norway	4.1%	6.4%	4.7%	0.2%	2.2%	4.0%	-2.8%
Poland*	-1.6%	6.0%	1.6%	3.0%	10.8%	4.1%	-0.1%
Portugal	4.7%	4.6%	7.4%	1.9%	5.3%	1.9%	0.4%
Slovak Rep.*	2.5%	2.5%	-3.9%	-0.9%	0.8%	0.2%	3.4%
Spain	5.4%	3.5%	3.1%	2.0%	4.2%	1.6%	-0.9%
Sweden	2.0%	5.5%	2.8%	2.1%	4.1%	2.0%	0.9%
Switzerland	-1.1%	-1.1%	-0.4%	0.8%	5.8%	-0.7%	0.3%
UK	3.0%	1.5%	7.8%	2.5%	6.6%	3.6%	-2.0%
US	4.4%	1.5%	2.6%	-0.8%	6.7%	4.0%	0.7%

Source: OECD STAN database, Groningen Growth and Development Centre database.
† Data periods for energy are variable.
* Periods as follows: Poland (1994-2001), Mexico (1988-2001), Czech (1993-2001), Hungary (1993-2001), Slovakia (1993-2001).

Table 2. **Sectoral labour productivity growth 1980-2001, % change**

	Agriculture	Forest, Fishing	Energy	Non-durable Manufact.	Durable Manufact.	Trade, Transport	Services
US, Canada, Australia, New Zealand	4.2	1.4	2.6	0.6	6.3	3.4	0.7
EU-15, other Western Europe	5.0	3.4	4.4	2.0	4.0	2.4	0.7
E. Europe, Central Asia	2.4	6.6	1.2	3.6	5.4	5.5	-0.4
Russia*	8.5	2.7	1.7	14.0	14.0	2.6	0.6
Japan	3.0	1.4	1.2	0.0	0.9	3.0	2.7
Korea, fast-growing Asia	7.1	4.1	9.0	4.2	14.3	3.2	0.8
China	4.1	4.1	3.0	4.0	4.0	1.0	1.0
India	2.8	6.6	6.3	3.0	7.5	3.5	3.2
Brazil, Central/South America†	2.7	2.7	2.3	1.0	4.8	0.7	1.5
Rest of World‡	3.4	4.6	3.5	3.1	5.1	1.9	1.5

Source : OECD STAN database, Groningen Growth and Development Centre database, ILO (2002), others .
* Based on data from 1999 to 2003.
† Based primarily on data from Brazil and Mexico, but also incorporates limited data from other countries.
‡ Average of non-OECD where data was available.

5. Changes in purchasing power parity exchange rates: the case of China

The phenomenon of changing PPP exchange rates in developing countries can be easily illustrated by comparing the cases of China and the United States. Taking the year 2001 as a reference point, Table 3 shows the share of each sector in total consumption in the Chinese and US economies.[3] This provides a backdrop for considering the degree of sectoral change that China is likely to undergo as it develops. For example, the share of agricultural products in household expenditures will fall considerably over time.

Table 3. **Relative sector size in 2001**

Sector	**Share of sector in consumption (%)**	
	China	**United States**
Agricultural Products	20.4	0.6
Forestry & Fishing	2.6	0.1
Electricity	0.7	0.8
Other Energy	1.3	0.8
Meat	1.8	1.2
Other food	16.0	5.3
Pulp, paper and publishing & Wood products	1.2	1.7
Motor vehicle	0.1	2.6
Chemicals	2.7	2.4
Other manufactures	23.4	7.0
Trade and transport	16.2	23.4
Services	9.9	42.5
Dwellings	3.3	11.0
Other Goods	0.4	0.6

Source: GTAP version 6 database

As Table 3 shows, the relative sizes of various sectors differ considerably between the two countries. Differences in sectoral productivity growth within each country are expected to lead to changes in these proportions over time. For reasons outlined in Baumol (1967), it can be expected that the service

3. These sectors represent consumption in the GTAP database. They reflect goods that are produced and go to final consumption, without being bundled into more traditional consumer goods and services.

sectors will experience slower productivity growth over time, and thus become a continually larger share of the overall economy. Table 4 illustrates the changes in sector shares in the USA and China that ENV-Linkages suggests will occur between 2002 and 2030 – based on historical rates of productivity growth in various sectors. Notice that since there is overall growth in both economies, a decreased *share* does not necessarily imply decreased *output*. Price changes are also shown to illustrate the common observation that technological advance will generally *lower* the prices of related goods and services.

Table 4. **Productivity-induced changes in China to 2030**

Sector	Change from 2001 to 2030 (%)	
	Change in consumption share	Price
Rice	-55	22
Other crops	-62	-2
Livestock	-41	3
Forestry	-12	57
Fishing	-9	153
Coal	37	2
Crude oil	0	-20
Electricity	39	-26
Gas distribution	39	-8
Natural gas	29	-24
Refined oil	-9	-23
Minerals	-12	62
Meat	-45	-7
Other food	-49	-4
Pulp, paper and publishing	-28	-29
Wood products	-27	-22
Ferrous metals	-25	-17
Non-ferrous metals	-25	-12
Motor vehicle	-29	-30
Chemicals	-28	-26
Other manufactures	-33	-31
Water	41	-28
Construction	37	8
Trade and transport	56	-9
Services	122	15
Dwellings	215	-43

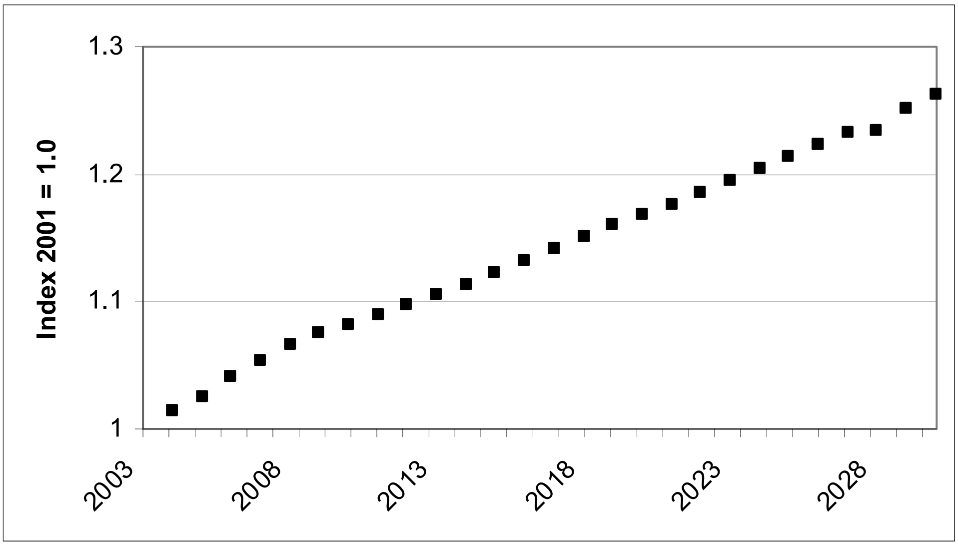
Sectors exhibiting slow productivity growth will therefore gain in dominance, and in general they will have falling prices. In effect, sectors producing goods and services that people want, but which are not experiencing rapid productivity growth, will appear to be sectors which are becoming a larger share of the economy. This is because the sectors experiencing rapid productivity growth require less and less of the economy's resources to produce them, while the opposite is true for sectors with slow productivity growth. To see this point more concretely, consider medical services. It is difficult for a doctor to increase the number of patients being seen each hour because of the nature of the services being rendered. In other words, there is little apparent productivity growth.[4] If other sectors of the economy have rapid productivity growth which leads to falling prices for (non-medical) services, then, if the need for medical services does not decrease, the price of those services must be increasing (relative to the other goods).

4. Abstracting from any improvement in the effectiveness of a doctor's advice on the patient's health – which would have to be measured as increases in longevity or quality of life.

When this distinction between economic sectors and their rates of productivity growth coincides with tradability of the products being produced by those sectors, there will also be an impact on the calculation of PPP. That is, when non-traded goods also have low productivity growth, their price will rise relative to other goods, leading the PPP-based measure of income to rise. Since the MER-based measure of income is calculated based on international transactions (the market exchange rate), it is not affected by the price of domestic goods and does not rise with PPP. More specifically, measuring the value of a PPP consumption bundle in China in 2001 will combine low-value low-productivity domestically produced/consumed goods with high-value goods that compete on international markets. Over time, those low-value goods and services currently available in the domestic Chinese economy will rise in relative price. The consumption bundle in China will therefore evolve to look more like its counterpart in the United States (at least in terms of the value of domestic goods and services relative to international ones). In other words, the purchasing power parity exchange rate should be increasing in China relative to that in the United States.

Calculating the price of consumption bundles in China from 2001 to 2030 gives results that are consistent with this intuition. In fact, the purchasing power parity exchange rate for China increases by 26% vis-à-vis that of the United States.

Figure 3. **Purchasing power parity exchange rate, China**



This result suggests that correctly accounting for differential productivity growth between sectors of the economy can explain to a significant degree the changing PPP exchange rate that is observed in developing countries. If effect, changes in PPP rates are *endogenously* produced by the development process itself. This is an improvement over the technique used in some long-term projections to impose an *exogenous* evolution of PPP. In many cases, this exogenous evolution is achieved by having a functional relationship between PPP and MER that is derived from the trend illustrated in Figure 1. As this paper illustrates, however, such an *ad hoc* approach misses some important underlying phenomena that are important for environmental issues, such as decoupling.

6. Conclusion

Ongoing discussions in various fora regarding development of baselines for long-term analysis, usually apply these baselines to environmental issues. This paper demonstrates that a good representation of economic phenomena is indispensable for good long-term environmental policy analysis. Without a proper accounting of the economics of long-term growth, some important facets of that growth for the environment are either missed, or have to be introduced in *ad hoc* ways. When their treatment is *ad hoc,* they can not be fully studied for their interaction and response to particular environmental policy initiatives. In particular, correctly accounting for differential productivity growth between sectors of the economy can explain to a significant degree the changing PPP exchange rate that is observed in developing countries.

The other major conclusion that emerges from this work is that the PPP versus MER "issue" becomes less central when a well-specified economic model is used. Since PPP-based measures of income will endogenously change, relative to MER measures of income, the evolving convergence between the two becomes an *indicator* of good analysis, not an *objective* that must be exogenously imposed.

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