New evidence suggests absolute decoupling in some economies, but is it enough and will it last?

Background

Does economic growth inevitably lead to more emissions of pollutants, and specifically of greenhouse gases? In previous posts I've shown that to date, claims that economic (GDP) growth is decoupling from greenhouse gas emissions (measured in CO_2e[1]) do not stand up. The claims either failed to cite sources, were only based on energy-related or on territorial (rather than consumption) emissions[2], or only demonstrated relative decoupling (reduction of rate of emissions growth) rather than absolute decoupling (an actual reduction in emissions while the economy increased in size).

New evidence

Now, however, new research has been published that does seem to provide evidence for absolute decoupling, in some national economies, even when outsourced emissions are included (i.e. using consumption or total emissions rather than territorial emissions).
In this post, I will review the strength of that evidence, and consider what it means in relation to a) the thesis that emissions can be decoupled from economic growth, b) that this will be sufficient to the climate change challenge facing humanity.

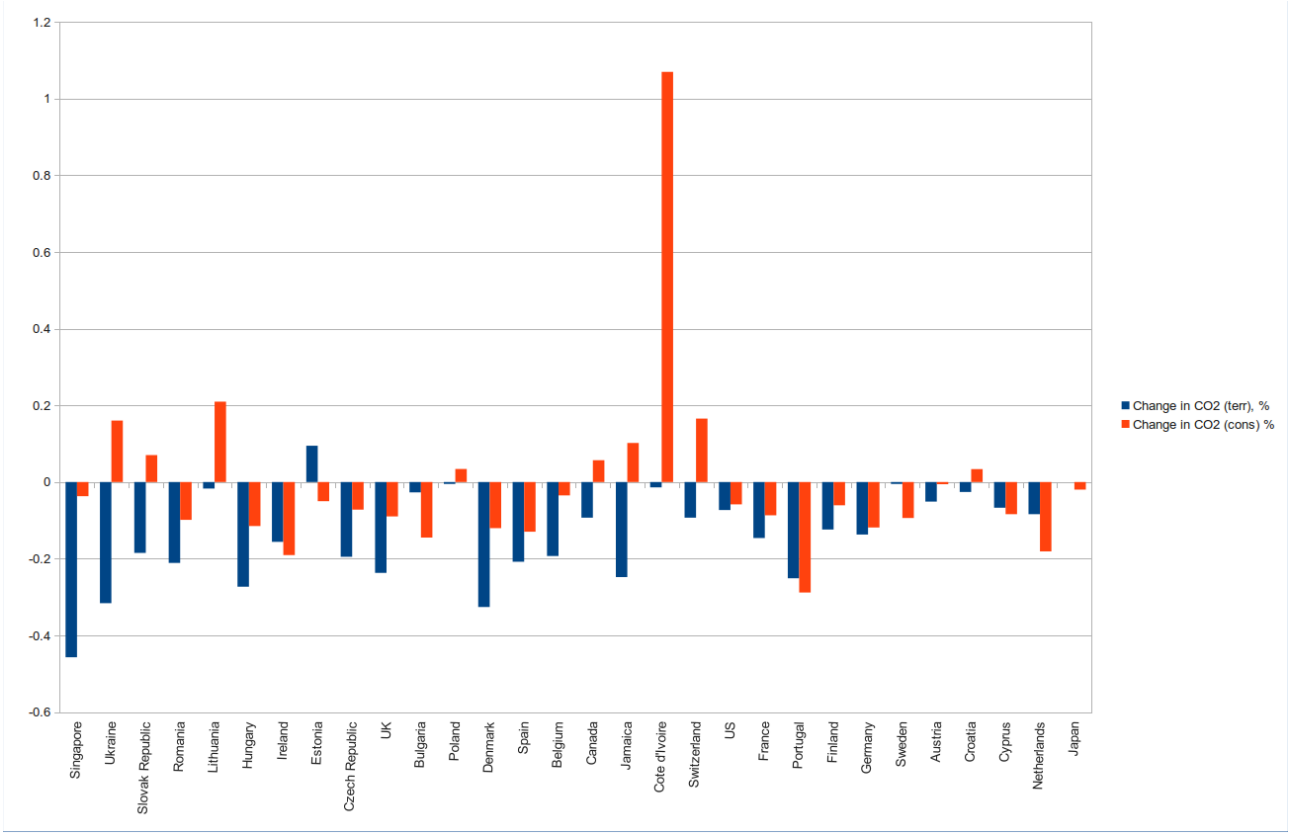
The evidence

The most recent research has already been covered widely in the press. The New York Times for example carried an article with the headline, Signs Are Promising That Economies Can Rise as Carbon Emissions Decline. This article by Coral Davenport gives a helpful resumé of the work done by Nathaniel Aden at the World Resources Institute (also covered in a Guardian article by Fred Pearce that is worth a read). This study examined the relationships between GDP and CO_2 emissions for each country. It found that in 21 countries, territorial emissions have decoupled from GDP growth, looking at the period 2000 to 2014. My first reaction was that this yet again concerned territorial emissions, so I looked at the corresponding consumption emissions. In fact, Sophie Yeo and Simon Evans of the

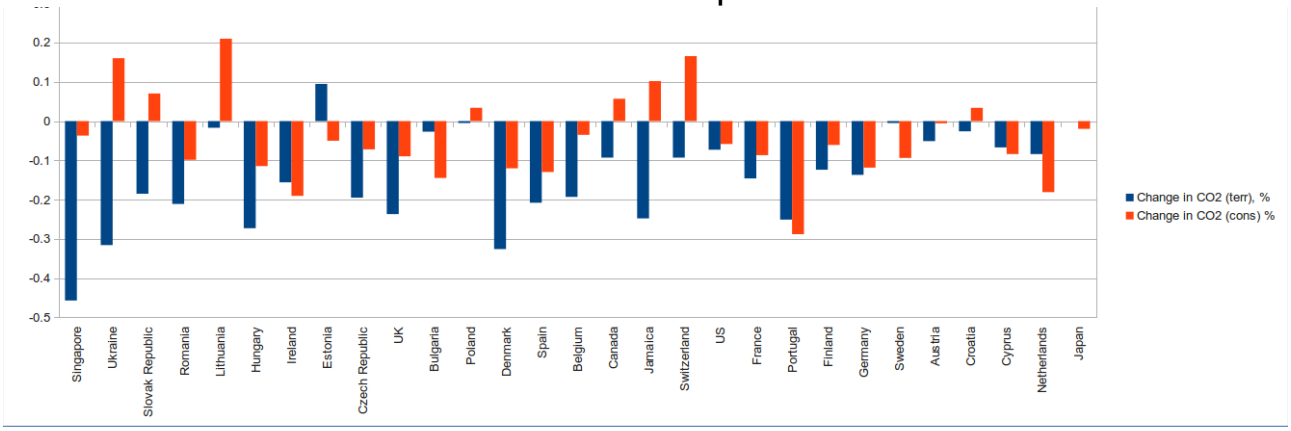
UK-based *Carbon Brief* did the same thing. First they extended the data set to include all countries, not just the 65 in the BP database used by Aden in the WRI study. They used the *Global Carbon Project* data. This yielded a total of 35 countries where territorial emissions reduced while GDP grew. Then they looked at the consumption emissions. It is worth quoting their finding on this latter critical point:

> *Only 21 countries decoupled their economic growth from consumption-based CO_2 emissions, between 2000 and 2013. This suggests some countries were only able to decouple by "offshoring" some of their emissions to other countries.*
>
> *However, major economies including the UK, US, France and Germany still decoupled, even after accounting for the CO_2 contained in imported goods.*

I have used the same data to produce the following graphs that show the relationship between the territorial and consumption emissions for the 28 countries in the original group of 35 for which there is consumption emissions data available, plus Estonia. First these 29 countries:



The outlier is Côte d'Ivoire. I don't know exactly what's been going on there, but while it reduced its territorial emissions by 1.4%, its consumption emissions have increased by a staggering 106%. Whatever the reasons for this, the other country data is easier to see if we take Côte d'Ivoire out of the picture:



Singapore, Ireland, Bulgaria, Portugal, Sweden, Netherlands, Cyprus and Japan (8 countries) actually, and to varying degrees, made bigger cuts to their consumption emissions than their territorial emissions. In addition Estonia reduced consumption emissions while increasing territorial emissions. However, all the other countries did

less well on consumption emissions than on territorial emissions. In addition to Côte d'Ivoire, Ukraine, Slovak Republic, Lithuania, Poland, Canada, Jamaica, Switzerland, and Croatia (9 countries) all failed to decouple consumption emissions,. The others, Romania, Hungary, Czech Republic, UK, Denmark, Spain, Belgium, USA, France, Finland, Germany and Austria (12 countries) all showed evidence of decoupling consumption emissions but less than they decoupled territorial emissions. Carbon Brief, then, are correct to say that a group of 21countries[3] show evidence, *on these data*, of decoupling their consumption-based emissions from GDP growth. Here is a table summarising all this.

Country	Change in CO_2 (Territorial), %	Change in CO_2 (Consumption) %	Change in real GDP, %	Territorial reduction less than consumption reduction?
Singapore	-0.457	-3.70%	107.50%	YES
Ukraine	-0.316	16.02%	49.50%	NO
Slovak Republic	-18.50%	7.03%	74.60%	NO
Romania	-21.10%	-9.87%	65.30%	NO
Lithuania	-1.70%	20.97%	79.70%	NO
Hungary	-27.30%	-11.47%	29.00%	NO
Ireland	-15.60%	-19.05%	47.40%	YES
Estonia	9.46%	-5.00%	63.60%	YES
Czech Republic	-19.50%	-7.19%	40.10%	NO
UK	-23.70%	-8.98%	27.10%	NO
Bulgaria	-2.70%	-14.49%	61.70%	YES
Poland	-0.50%	3.39%	62.60%	NO
Denmark	-32.60%	-12.03%	8.30%	NO
Spain	-20.80%	-12.96%	19.70%	NO
Belgium	-19.30%	-3.50%	21.10%	NO
Canada	-9.30%	5.68%	32.40%	NO

Country	Change in CO_2 (Territorial), %	Change in CO_2 (Consumption) %	Change in real GDP, %	Territorial reduction less than consumption reduction?
Jamaica	-24.80%	10.18%	9.40%	NO
Cote d'Ivoire	-1.40%	106.99%	40.00%	NO
Switzerland	-9.30%	16.55%	28.30%	NO
US	-7.30%	-5.83%	28.10%	NO
France	-14.60%	-8.68%	16.30%	NO
Portugal	-25.10%	-28.82%	1.20%	YES
Finland	-12.40%	-6.07%	17.80%	NO
Germany	-13.70%	-11.85%	16.00%	NO
Sweden	-0.50%	-9.38%	30.60%	YES
Austria	-5.10%	-0.56%	21.10%	NO
Croatia	-2.60%	3.36%	22.60%	NO
Netherlands	-8.40%	-18.09%	15.10%	YES
Cyprus	-6.70%	-8.4%	21.70%	YES
Japan	0.00%	-1.98%	10.90%	YES

Discussion

Questions about emissions data.

These findings surprised me. But what do they really tell us? Firstly I'll look at some questions about the data. This is not to criticise the work of either WRI or Carbon Brief, but to note a number of uncertainties about the data that they used and which I have also gone through, replicating their analysis.

Accuracy of country-level data and missing emissions

The data analysed is taken from two sources: The BP Statistical Review of World Energy and the Global Carbon Budget Project, part of the US Department of Energy's “Carbon Dioxide Information

Analysis Center". The latter source takes its information on territorial emissions from the UN Framework Convention on Climate Change, whose sources are based on the individual country submissions. Where these are not available, BP data is used. Consumption emissions are taken from the Global Carbon Budget Project which relies heavily on research by Glen Peters of the University of Oslo, working with a number of colleagues in various countries: the data from the Peters et al. 2011 article is used, updated, but we don't know exactly how. Without going into great detail, there are a number of issues with these various sources of data.

1. Variability in the quality of data reported by countries. China's emissions data has been questioned before but the same concerns about inaccuracy are likely to apply to the data from some other countries.
2. The use of different reporting protocols by different countries. This is a historical legacy of Kyoto – some countries are newcomers to emissions reporting.
3. Emissions from international transport (i.e. shipping and aviation) are reported by individual countries but not included in their totals: they are included in the global total of emissions. This is an important matter since when considering those emissions that arise from consumption of imported goods and services, these emissions are obviously a relevant component.
4. There may well be other missing data, for example the scale of "fugitive" emissions from the petrochemical industry could be larger than estimated as demonstrated in recent work on methane escapes from shale gas (fracking) in the USA, or the increasing emissions from submarine hydrides and melting permafrost which might, or more likely might not, feature in country territorial emissions figures.
5. The methodology for arriving at consumption emissions is even more complex.
   "*Although all emissions inventories have some uncertainty, including territorial emissions, consumption-based estimates will have larger uncertainty due to the incorporation of more input data, each with various levels of uncertainty." (Barrett at al., 2016, p. 457).*
   Two methods are used by the Peters group, but the most accurate one, the Multi-Regional Input–Output (MRIO) model

was only possible for three years (1997, 2001, and 2004) due to data limitations. The simpler Embodied Emissions in Bilateral Trade (EEBT) model is used in the majority of years, or rather a variant of this is used: To avoid the time-lags and construction of an annual global database, *"we develop a method to approximate the EEBT method with the components of the Gross Domestic Product (GDP)."*
Perhaps unsurprisingly, other researchers have reached rather different conclusions about the impacts of outsourced emissions: in a 2014 study, Kanemoto et al., using a different MRIO database, found that "*adjusting for trade, developed countries emissions have increased, not decreased*" and that *"the sectors successfully holding or lowering their domestic emissions are the often the same as those increasing their imports of embodied CO2. This suggests that it is not cleaner production or consumption patterns that are reducing domestic emissions, but simply burden-shifting of the same emissions-intensive activities"*.
The Kanemoto Sydney model finds greater levels of consumption emissions than the Peters Oslo model while a further model from the University of Leeds finds still higher levels although in general they all move in the same direction showing the same general trends.
A further problem is with the number of assumptions made in using these models, such as the use of monetary values as proxies for material flows, and the reduction of diversity in various exports to country-wide averages. For a full review of the complexities of calculating consumption emissions see Sato (2013), who concludes that although attempts at measurement are worthwhile and revealing of the nature of the problem, *"quantities of [emissions embodied in trade] at the country level remain highly uncertain for most countries and years"*. And it is worth noting that the uncertainties about territorial emissions apply also to estimates of consumption emissions since the methodologies for calculating them use exporting and importing countries territorial data as input to their calculation.

Questions about GDP data

GDP is also a complex, composite index (see World Bank definition), with many assumptions in its calculation. Leaving aside whether it measures something meaningful, there are methodological problems here too and these apply to its calculation for every single country.

Firstly, it is necessary to have accurate information on the sectors of each country's economy, and countries differ widely in the areas that are hidden from the official statistics (the informal economy, the criminal economy and transactions hidden from the official gaze legally or illegally for tax avoidance/evasion), in the level of expenditure on public services (which to only varying degrees can be equated to economic activity such as production) and financial services (of which more later), and in the quality of data collected. Secondly, that data needs to be aggregated – and a variety of assumptions are made in doing this, as well as the use of estimates for missing data. See this and this piece for discussion of some of these issues. Finally, it has to be reported, and governments may have incentives for varying degrees of presentational inaccuracy.

It should be noted that, as seen above, GDP figures are themselves used in arriving at the estimates of consumption emissions, which again involves some assumptions about costs and prices.

So, the question of understanding the relationship between the growth of the economy and emissions rests on data sets that have, at best, considerable margins of error. The analyses by WRI and Carbon Brief do not cite “confidence limits”, or similar estimates of error, for either the variables or for the dependability of the relationships they identify – and indeed that would be a difficult task, given the heterogeneity of the “data behind the data”. However, the Barrett et al. article, reviewed recently by Carbon Brief does exactly this for the UK data, although only up to 2004: these estimates though are themselves based on the known variation within the data rather than the “known and unknown unknowns” that beset such ambitious enterprises. There is a tendency, particularly in the secondary literature, to give the impression that these data are the “real thing” rather than socially mediated estimates.

Issues of interpretation

We turn now to problems of interpreting the relationships between GDP growth and emissions reduction that have been reported. Let's make the charitable assumption, for the moment, that the datasets are perfectly reliable[4]. What could account for the changes?

1 Energy mix

It may be that the way energy is produced has become less carbon-intensive. That is to say, for each joule of energy produced, fewer molecules of greenhouse gases are produced. And for economies decarbonising both territorial emissions and consumption emissions, this would be happening at home and in enough of the economies producing goods and services that are imported.
We know that this has been happening. Globally, energy emissions have recently stalled, although not reduced (except in 2009 and in the early 1980s) and this is attributed to a reduction in the use of coal (the most carbon-polluting hydrocarbon source, used for electricity generation and in our declining steel industry) and to the growth of renewables. In the case of the UK, a similar but stronger picture can be seen with falls in territorial emissions in 2015 to 38% below the 1990 level (figures from Carbon Brief). For the first time, renewable energy generation surpassed coal (although this includes biomass, much of it using imported wood, substituting for coal, with the shipping emissions excluded from analysis). Changes in energy use internationally will also feed into the consumption data, for example, the two biggest sources of UK imports are the European Union and China, both of which have been ramping up renewables investment.

2 Composition of GDP growth

As we noted above, GDP is a composite of economic activities. It is perhaps no surprise that the big reductions in total emissions are seen after the Great Financial Crash of 2008 A number of things have been happening in the economies concerned since then. For illustration I will focus on the UK economy.
Between 2007 and 2011, households began repaying their debts:, UK net household saving went from more than MINUS £30Bn to PLUS £20Bn. That is to say there was a shift from consumption

fuelled by credit to holding money in savings and investment accounts. This was in the context of static or reducing incomes: it is therefore not surprising if consumption decreased. However, from 2011 the pattern reversed with savings reducing and credit card debt increasing. Yet by 2013 (the last year of data in the consumption emissions analysis), household expenditure had only just recovered to its 2007 (pre-Crash) level in real terms according to ONS data and real wages are still below 2008 levels.

Since 2010, austerity has hit household spending in the UK hard so whatever the GDP figures are telling us, swathes of the population have less to spend on goods and services. While the GDP figures have risen, much of that has been dependent on "asset price inflation" (principally house prices in London and the South East). There are several aspects to this, including the siphoning away of housing proceeds to non-UK economies (due to speculative purchases by non-residents) and a rising proportion of UK citizen expenditure on rent rather than on consumption. These factors together mean that there is not a one-to-one relationship between economic growth and consumption: available statistics do not make it easy to unravel these relationships but we should be cautious in assuming that GDP rises necessarily equate to consumption increases. That means that a simple relationship between GDP growth and indices of GHG emissions will not apply under all circumstances. We need more sophisticated tools for understanding these relationships.

But what about the other economies? Several of the decoupling nations are European Union countries, and austerity policies there are likely to have had similar downward effects on consumption levels. This led me to look again at the most impressive decoupling countries. Household consumption as a percentage of GDP declined in the 2000-2015 period in 6 of the 8 countries whose consumption emissions reductions exceeded their territorial ones. Using World Bank Data on Final Household Consumption[5], the percentage change for these countries from 2000 to 2014 was,

Singapore	-9.95% (decrease)
Ireland	-5.87% (decrease)
Bulgaria	-4.82% (decrease)
Portugal	4.24%

Sweden	-1.27% (decrease)
Netherlands	-10.63% (decrease)
Japan	7.41%
Estonia	-10.55% (decrease)

In a majority of these cases, then, a reduction in consumption by households will have contributed to the overall national decoupling.[6] It does not account for all the difference but there will be other associated reductions in consumption-related activity, elsewhere in the economy, not reflected in the figures for households (an inverse multiplier).

A further factor is the financialisation of the economy. In the UK and the US, as well as in many other "developed" economies, the share of GDP accounted for by non-productive financial growth (interest, speculative asset growth) rose over the period in question. Owners of this new capital have sought to make further profit, not from productive sections of the economy but from further financial "rent-seeking". While credit growth has fuelled consumption, by allowing household expenditure in the face of static or falling real incomes, the ballooning profits appear to be much larger than this domestic "feedstock". So financial growth, as a significant proportion of GDP growth, is not all directed at increased consumption. The same goes for Quantitative Easing which has been criticised for not aiding the productive economy but instead adding to asset bubbles.

There is not the space for further analysis here, the point however is that GDP rises do not necessarily translate into consumption rises in the short term.

3 Population changes

The "real GDP" figures used by Carbon Brief control for prices but not for population changes. Some of the decoupling economies have had high levels of emigration. Remittances in these cases will, on the one hand, have inflated the GDP figures for these countries but there are also fewer people consuming in the home country. Now a converse argument could be made for countries like the UK and US (whose populations have grown as a result of migration): the point is that again, these processes need to be unravelled before we can say with any confidence that we have a relationship.

4 How durable are these changes likely to be?

Since it is not clear what is underlying the apparent decarbonisation in selected economies, it is unclear how durable these changes may be. It may be that a set of short-run factors are combining, post Great Financial Crash. Some of these, such as the switch from coal, are positive and in themselves unidirectional, but others (particularly the phenomenon of "ungrounded growth" explored above) are potentially reversible. Even changes in energy usage patterns could, over time, be wiped out by rebound elsewhere in the economy, or by under-estimation of factors such as methane leakage, biofuel carbon emissions or from loss of sequestration and methane emissions following megadam projects.

Conclusions

We have two main areas of uncertainty and three areas of certainty:
1) *We cannot be sure what the findings of decoupling in selected economies really mean because of problems of data quality, missing data and the "construct validity" of measures* – i.e. are they actually measuring what they purport to? When we then look for relationships between the variables, the uncertainties increase. Moreover, they do not demonstrate a causal relationship: the relationship could in many cases be a result in the dissociation of consumption growth itself from overall GDP growth. At best there is only an association: practically you can't point to say the Estonian or UK economy and say "do this", although some of the things that have been done will indeed be helpful.
2) *There is also uncertainty about the durability of the observed effects* because they may reflect one-off or reversible changes, or they may under-estimate emissions.
3) *Only some economies show these apparent effects.* Even if these findings reflect a solid relationship between the growth of some economies and emissions reductions attributable to them, they would be just that, an effect in only some economies. **Meanwhile, global emissions in the period 2000 to 2014 increased by 45%.** (By definition territorial emissions equate to consumption emissions globally). So **the global economy, is far from decoupling its emissions** from its expansion.

4) *The rates of emissions reduction in the apparently decoupling nations would be nowhere near sufficient to avert the climate catastrophe. As Anderson and Bows have shown,* the Annex 1 nations (that includes most of the apparently decoupling countries) **need to be reducing emisions at between 8 to 10% p.a. The figures in the above table do not give annual rates above 2%.** As Anderson and Bows note, *"From Stern and the UK's Committee on Climate Change through to virtually every 2°C emission scenario developed by 'Integrated Assessment Modellers', reductions in absolute emissions greater than 3% to 4% year on year are judged incompatible with a growing economy."*
This would seem to put degrowth firmly back on the agenda since to achieve radical emissions reduction, we need a global economy that is considerably smaller, in material terms, and the only socially justifiable course becomes "living better with less".
5) And **while measurement of emissions may have its flaws, we know that global CO2 concentrations continue their ever upward path**, and that is a path that, if anything, appears to be accelerating.

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1 CO_2e means CO_2 equivalent. Other greenhouse gases (including Methane and the Nitrogen Oxides) have a greater insulating effect than Carbon Dioxide but are emitted in smaller quantities. CO_2e provides a convenient single indicator that converts the greenhouse effect of these other gases to the amount of CO_2 that would produce the same impact and then adds that to the CO_2 figure.

2 Territorial emissions are those emitted within the borders of a country. Consumption emissions are those attributable to all the services and products consumed by a country. As will be seen, territorial emissions are the easiest to measure and are the basis from which consumption emissions are calculated. Rich country economies have typically "outsourced a lot of their production of goods and services that are produced in other countries: therefore territorial emissions do not give a representative picture of the planetary impact of these economies, nor conversely of the economies where this production takes place. The UK has done this to a greater extent than other countries.

3 I make it 20, not 21.

4 Reliable but not necessarily valid.

5 *"Household final consumption expenditure (formerly private consumption) is the market value of all goods and services, including durable products (such as cars, washing machines, and home computers), purchased by households. It excludes purchases of dwellings but includes imputed rent for owner-occupied dwellings. It also includes payments and fees to governments to obtain permits and licenses. Here, household consumption expenditure includes the expenditures of nonprofit institutions serving households, even when reported separately by the country. This item also includes any statistical discrepancy in the use of resources relative to the supply of resources."*

6 For the countries that decoupled consumption emissions, but at a lower rate than their territorial emissions, the picture is similar (decreases, or very small increases in household consumption) with the exception of the outlier Cyprus:

Romania -8.17% (decrease)
Hungary -7.27% (decrease)
Czech Republic -4.49% (decrease)
United Kingdom 0.16%
Denmark 3.21%
Spain -2.37% (decrease)
Belgium -1.95% (decrease)
USA 3.76%
France 1.93%
Finland 1.93% (2000-2008)
Germany -4.44% (decrease)
Austria 0.01%
Cyprus 13.28%