

EXECUTIVE SUMMARY

Green productivity measurement

The twin challenges of the economy and climate change have in the past been pitted against each other. The “de-growth agenda” suggests that in order to tackle global warming, we must reduce economic growth. Some “growth agendas” would have us jeopardise environmental goals by renewing fossil fuel projects in the name of economic growth.

But are environmental action and economic growth mutually exclusive? Could productivity growth drive both economic growth, and the Net Zero transition? Productivity determines the scope for increasing prosperity, but the current model of Gross Domestic Product (GDP) does not measure environmental issues. Economic statistics that can simultaneously assess progress towards productivity growth and Net Zero will be needed.

Our research contribution is two-fold: we believe we are the first to treat environmental protection expenditure as capital investment in the UK context; and, where previous studies have incorporated emissions into economy-wide productivity measures, we utilise the richness of UK data to construct sector-specific environmentally-adjusted productivity for 42 industries.

Introducing environmental factors into productivity estimates

Conventional productivity measures ignore ‘bad outputs’ such as pollution. But as pollution and climate change become increasingly important socioeconomic concerns, their exclusion from productivity statistics becomes increasingly problematic.

A comprehensive productivity measure would consider all inputs that produce output, where output is total output (or gross output), and inputs are labour, capital (including tangible, intangible, and natural capitals), and intermediate inputs (goods and services used up in the production process). The UK official productivity measures produced by the Office for National Statistics (ONS) use gross value-added (GVA) as the output measure.

This new research explores four ways to measure productivity adjusting for environmental factors in the UK, introducing natural capital into the mix. They are:

- examining energy-productivity;
- incorporating greenhouse gas (GHG) emissions as an input;
- incorporating GHG and non-GHG air pollutants as ‘bad outputs’;
- and incorporating environmental protection as a ‘good’ output.

Measure	Definition	Adjustments to GVA
Energy-productivity	$\frac{GVA}{Energy\ Use}$	
Emissions-productivity	$\frac{GVA}{Greenhouse\ gas\ emissions}$	
Labour productivity with bad outputs	$\frac{GVA -}{Hours\ Worked}$	Value of greenhouse gas emissions and air pollutants are deducted from GVA
Labour productivity with unmeasured environmental investment	$\frac{GVA +}{Hours\ Worked}$	Value of unmeasured environmental protection investments are added to GVA

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Chart 1: Real GDP, energy use and greenhouse gas emissions, 1990 to 2019, index 1990 = 100

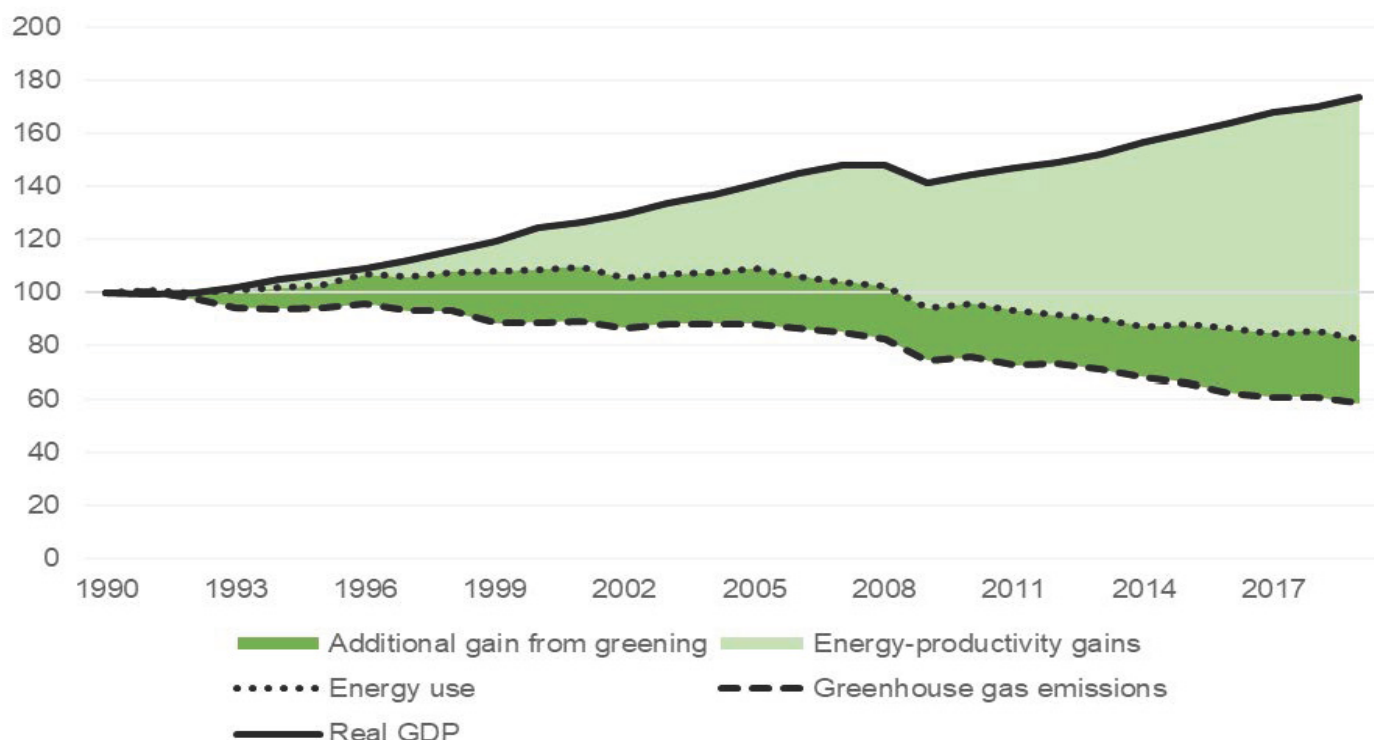


Chart 1, created from the research, shows that between 1990 and 2019:

- real GDP grew around 75%
- the amount of energy used in the economy fell by about 20%
- greenhouse gas emissions fell about 40%

It proves that economic growth can be achieved while reducing certain types of environmental damage.

The difference between the growth of GDP and the (negative) growth of energy or emissions can be thought of as productivity measures.

- **Productivity** is how much output can be produced per unit of input, so in this case the “input” would be energy, or ‘the environment’ (where emissions can be thought of as ‘using up’ the environmental input).
- **Energy-productivity** is then the growth in output less the growth in energy use, which is equivalent to the light green area in Chart 1. This has more than doubled since 1990.

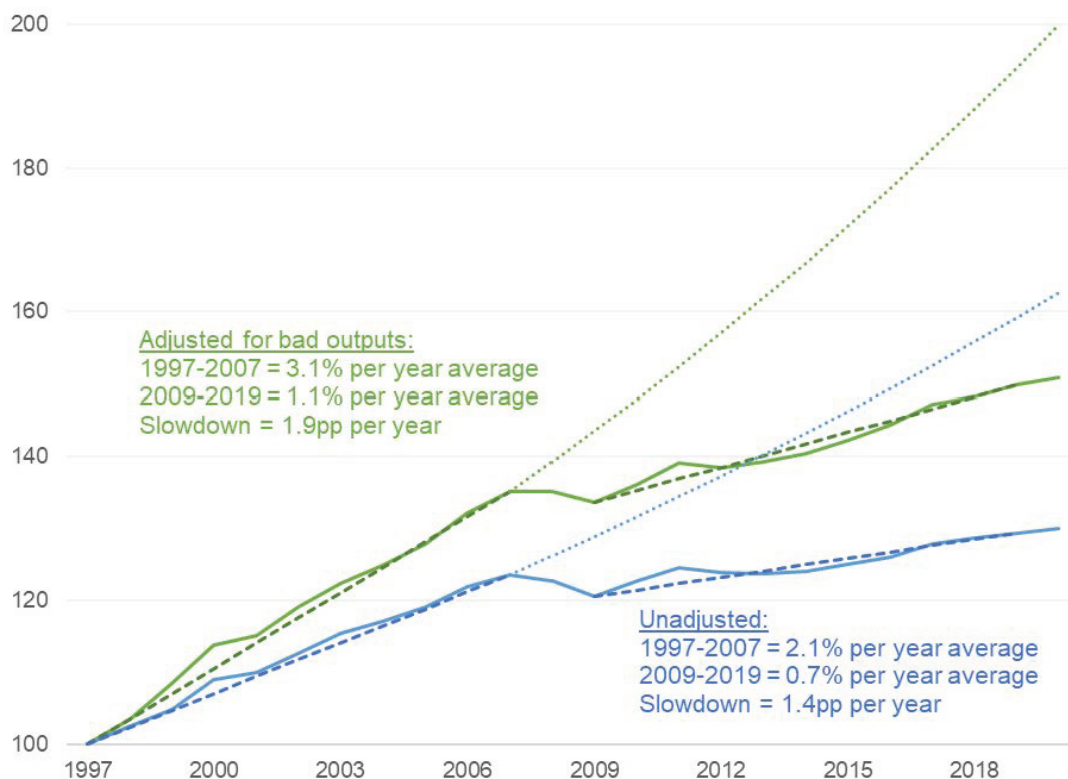
- **Emissions-productivity** is the growth in output less the growth in emissions, which is the darker green area plus the light green area in Chart 1. Since most emissions come from energy use, the gains in emissions-productivity can be thought to come mostly from the gains in energy-productivity, but with additional gains from ‘greening’ the sorts of energy used (moving from fossil fuels to renewables, for instance). This covers greenhouse gases only; some energy sources may emit less GHGs but cause more pollutants which are not captured.

The growth in energy-productivity and emissions-productivity **could** be just because of the changing industrial composition of the UK economy. Perhaps the transition from manufacturing to services industries is driving this change?

Using detailed industry data from ONS, this can now be answered: compositional changes account for only around 10-20% of the growth in aggregate energy-productivity and emissions-productivity, with the rest coming from improvements **within** industries.

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Chart 2: Whole economy labour productivity, with and without adjustment for bad outputs, with pre-downturn trends, 1997 to 2020



How to account for the environment in GDP

A different way of thinking about environmentally-adjusted productivity is not to change the inputs, but to change the output. Starting from a standard labour productivity measure (output per hour worked), how can the environment be accounted for in the output measure (GDP)?

One way is to treat the negative environmental side effects of production as a 'bad output' and subtract it from Gross Value Added (GVA). This is, in the jargon, internalising the negative externalities from greenhouse gas emissions and other pollutants.

This is done by estimating the cost of the emissions and pollutants, by multiplying the amount of emissions (e.g. 1000 tonnes of carbon dioxide) by a price (e.g. £273 per tonne). It's then subtracted from 'standard' GVA to get an environmentally-adjusted GVA measure, or "GVA-minus". This is done with all the greenhouse gases under the Kyoto Protocol, and

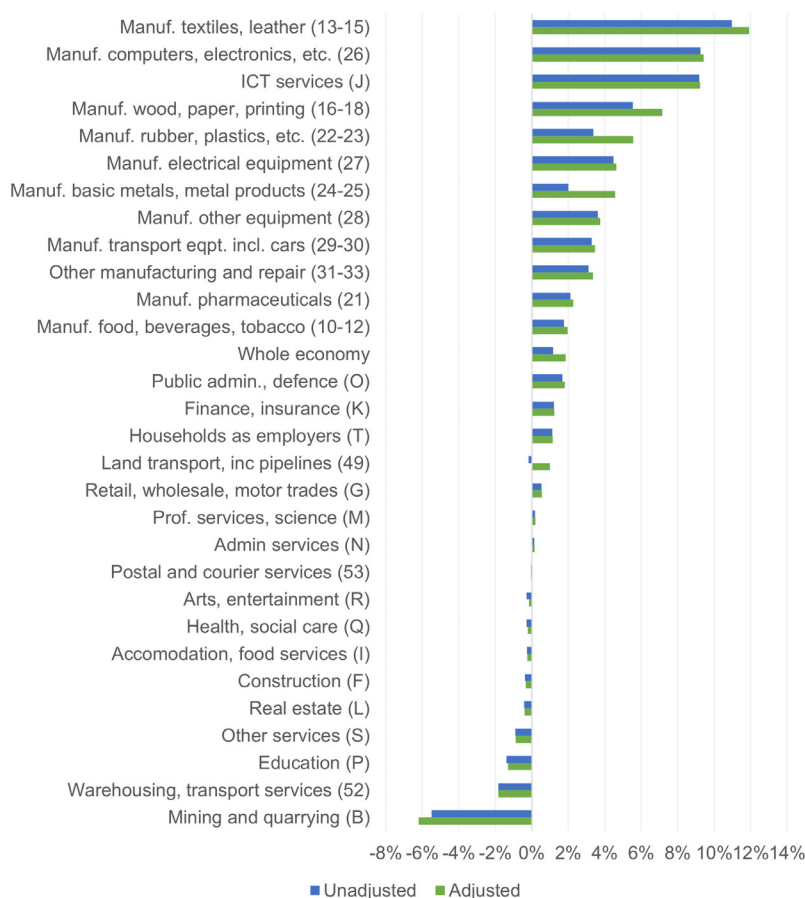
a range of other pollutants.

In some industries, the 'bad outputs' are so large that they outweigh the 'standard' output measure, such that GVA-minus is negative. That's true for the petroleum manufacturing and air transport industries, amongst others.

Since emissions have been declining, their negative effect on GVA-minus falls over time, and so GVA-minus grows faster than 'standard' GVA. That means labour productivity with bad outputs (GVA-minus per hour worked) grows faster than standard labour productivity, as Chart 2 shows. However, this faster growth occurs both before and after the 2008 financial crisis, so it does not make the productivity slowdown any less.

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Chart 3: Average annual productivity growth between 1997 and 2019, with and without adjustment for bad outputs, by industry



In Chart 3, the growth rates are only shown to 2019 to avoid the effects of the coronavirus pandemic. Further industry-level charts can be found in the full paper. Some observations:

- Most industries see faster productivity growth after adjusting for bad outputs
- Only two industries see slower productivity growth after adjusting for bad outputs - mining and quarrying (which is dominated by oil and gas extraction) and postal and courier services.

Capturing investment in protecting the environment

Businesses can incur costs to protect the environment but are not usually compensated for them and there is no corresponding output recorded. Capturing these (unmeasured) non-market outputs would increase GVA by a corresponding amount. These costs can be considered an investment in the environment as an asset as there is clearly value generated for the economy and society. This research explicitly measures the (currently unmeasured) environmental protection output produced by businesses, adds it to (measured) GVA, and recalculates productivity.

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Conclusion

- Incorporating emissions into productivity measures generally improves measured productivity growth in the UK in recent decades, but this varies across industries and environmentally-adjusted productivity measures.
- Mismeasurement is one of the explanations for the UK's productivity downturn since 2008. This research considers a different type of mismeasurement – the failure to account for environmental damage, and environmental protection activities. If businesses are increasingly incurring costs to reduce environmental damage, and this cost is not accounted for in output or prices, then measured output may understate the true value of that output, leading productivity to be underestimated. This does not seem to be the case based on the measures introduced in this research.
- There is more to be done to develop these measures, but they offer insights into the opportunities for productivity growth to support the Net Zero transition, and an opportunity to reflect on the way our economic statistics help us understand important economic and environmental challenges.
- Ultimately, our results constitute a rare 'good news story' in environmental economics: the UK is using energy more productively than ever, reducing the emissions intensity of GDP, and most importantly, there is significant room for further improvement across many industries.

Explanation of terms used

- **Gross Value Added (GVA)** is the measure of the value of goods and services produced in an area, industry or sector of the economy. It is total output less intermediate inputs (encompassing energy, materials, and services). For this research, it is taken from the **GDP output approach low-level aggregates** dataset from the ONS.
- **GVA-minus** deducts the value of emissions and pollutants from GVA
- **GVA-plus** adds environmental protection expenditure as a form of investment in natural capital to GVA
- **Tangible capital** is an asset that has physical substance such as buildings, machinery, and equipment.
- **Intangible capital** is an asset, usually knowledge-based, that is not physical, such as goodwill, brand recognition, intellectual property, software, patents, trademarks and copyrights. Intangible assets are difficult to value and those created by a company often do not appear on the balance sheet and have no recorded book value.
- **Natural capital** provides inputs and environmental services for economic production. This includes ecosystems, land, species (all living organisms from micro-organisms to animals), freshwater, soils and sub-soils (including fossil fuels), minerals, the atmosphere and oceans and coasts as well as natural processes and functions.
- **Bad outputs** included in this research are: greenhouse gas emissions (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, nitrogen trifluoride and sulphur hexafluoride), acid rain precursors (sulphur dioxide, nitrogen oxide and ammonia); and other pollutants (including small particulate matter, PM2.5).
- **The Economics of Biodiversity: The Dasgupta Review** was published in 2021 and is an independent, global review which calls for changes in how we think, act, and measure economic success to protect and enhance our prosperity and the natural world. This research was done in the spirit of this Review.