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Could Green Growth Be An Oxymoron?

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Key Takeaways

- Using a simple two-sector model to examine trade-offs between economic growth and its environmental impact, we show that higher output is no longer unambiguously positive; for example, greener output may be better for the environment than growth linked to the demographic dividend.
- Technological change takes on a broader meaning in our model where it can reduce the adverse environmental impact of a given output level, while its usual interpretation as a precursor of higher productivity, although still important, can no longer suffice in a world seeking sustainability.
- Green growth is possible when there's a balance between the negative environmental impact of economic activity and the sum of natural regeneration and man-made offsets (like carbon capture). But, to get to this outcome, the full economic and environmental costs of producing goods and services need to be measured and priced.

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Economic growth has traditionally been thought of as increasing the size of the pie. It also implies greater consumption possibilities, the ultimate goal of economic activity, rather than growth for the sake of it as is sometimes asserted. In short, for many theorists, more is better.

Why this matters: The traditional view of economic growth has largely ignored growth's environmental impact and how economic agents may value the environment. Indeed, while output and human and physical capital have been expanding in recent decades, the stock of natural capital has been declining (The Economics of Biodiversity: The Dasgupta Review).

What we think and why: The cost of economic activity on the environment has been underpriced, leading to environmental degradation. This has resulted from mispricing inputs, where the environmental impact of production has largely been absent from companies' actions and from the preferences of consumers and investors.

This brings us to a thorny question: Is environmentally sustainable or "green" growth even possible?

Modeling Trade-Offs Between Growth And The Physical Environment

If any type of economic activity can hurt the environment in some fashion, how can we get to a net-zero environmental impact and still achieve economic growth? One possible conclusion is that the economic pie must shrink in order to reverse or just contain the deterioration of the environment that has accelerated in recent decades. A more hopeful outcome is that some combination of more accurate pricing and technological improvements could make sustainable economic growth possible.

To explore these trade-offs, we developed a simple framework to show the interaction between economic output and its environmental impact: both negative and positive. The model serves as a tool to explore under what conditions green growth, by which we mean expansion of output that does not have an increasingly negative environmental impact, might take place, focusing on a few key variables.

Our model depicts a simplified economy, consisting of two sectors: "green" and "brown"

All economic activity in this model has a negative impact on the environment. Consequently, increasing the amount of green output or using innovation can only reduce the harm to the environment, not remove it entirely.

Each sector can be thought of as representing a group of sectors carrying out various economic activities.

- The greener the output, the lower the detrimental impact on the environment.
- The browner the output, the more damaging to the environment.

Since this is a high-level, conceptual model, we will not specify precisely which sectors are green or brown, or where the dividing line is between the two. But we can imagine that most services are in the green sector, while the heavier industries such as energy and construction are in the brown sector.

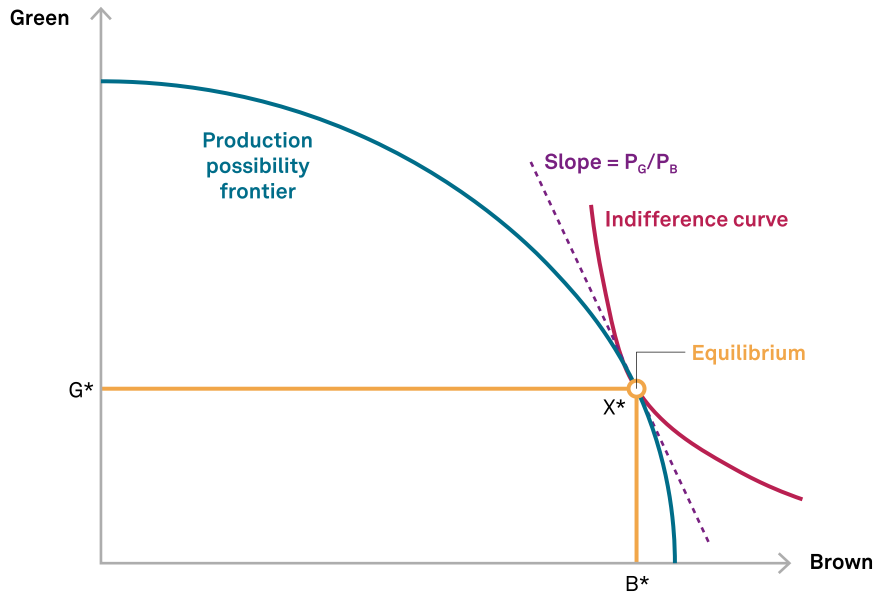
Production Possibility In Our Two-Sector Model

For our model, we first focus on the production possibility frontier (PPF) across different combinations of output for the green and brown sectors. The PPF shows what the economy can produce given its technological and resource constraints. This approach follows an established tradition of using two-sector models in economics. Examples include wine versus cloth to analyze the gains from trade dating back to the 18th century; guns versus butter during the Cold War in the middle of the 20th century; and goods versus services, more recently as many economies have de-industrialized.

Our PPF (see chart 1) shows the combination of green and brown output when the resources of the economy--labor and capital--are fully employed. Implicit to the model is the prevailing state of productivity or technology to combine these resources. Points outside the PPF are not feasible since they require more resources than are available, while points inside the PPF are inefficient, since not all resources are fully employed. The curve's concave shape reflects diminishing returns. Putting an increasing number of resources into either sector diminishes the incremental output from that sector.

Chart 1

Production possibility in a green-brown economy



Source: S&P Global Ratings.

While any point along the PPF is feasible to produce, where an economy actually produces on the PPF depends on preferences and prices. Consumers have preferences between green and brown goods, as shown by the indifference curve in the chart. Specifically, consumers are indifferent across all combinations of green and brown output along the curve. We can imagine a family of curves radiating out from the origin with increasing levels of welfare or usefulness. Note that, with this standard shape of the indifference curve, consumers in our model want both green and brown goods or services, meaning that the outputs from these two sectors are complements rather than substitutes.

Importantly, the equilibrium is unique: There is only one point where the economy is producing the most "efficient" combination of goods. This is also where consumer preferences are at the highest possible point on the indifference curve. At the equilibrium point (labelled X* on chart 1), the slope of the PPF and indifference curve are the same, providing the equilibrium relative price of the green good in terms of the brown good. X* also shows the equilibrium output of the green and brown sectors G* and B*, respectively. It is essential to remember that relative prices drive the allocation of resources and are derived from consumer preferences. The equilibrium point on the PPF shows that consumer preferences matter, not just growth.

Moreover, given the prevailing amount of labor and capital in an economy, there is only one PPF. If more of either input becomes available, the curve will shift out. And if less of either input becomes available, the curve will shift in. Technological progress or productivity gains (or losses) will shift the curve out (or in) as well. These shifts may not be symmetric in terms of their impact on the green and brown sectors. We now explore some of the implications below.

Efficiency Curves Help Illustrate Output's Environmental Impact

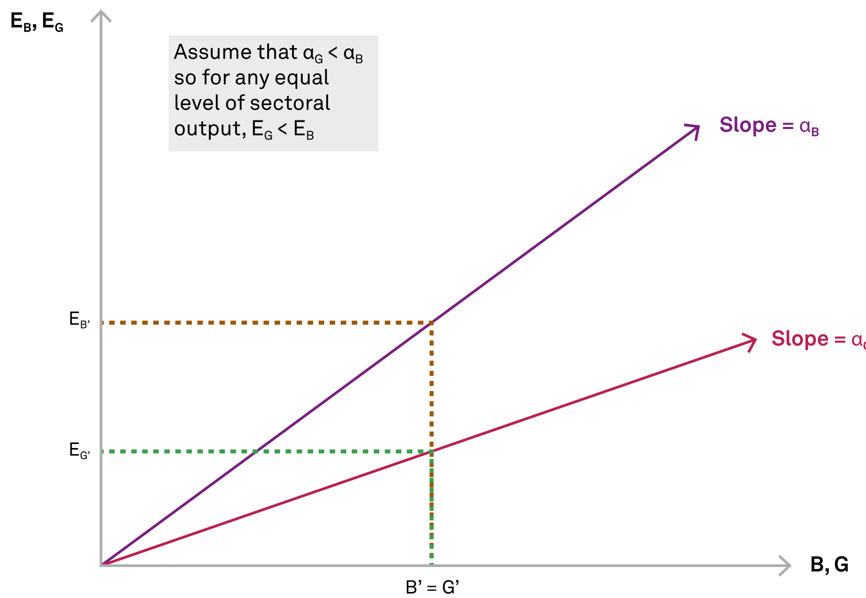
A central focus of our model is the interaction between economic activity and the environment; as such, we need to translate units of the former into units of the latter. We do this by introducing environmental efficiency curves, one of the key innovations in our framework.

We assume our environmental efficiency curves to be linear. This assumption is to keep the analysis simple and is not a representation of reality. The purpose of these curves is to translate the output (goods/services) in each of our two sectors into units that correspond to their impact on the environment. This can be interpreted as the overall environmental footprints, of which greenhouse gas emissions could be a principal component. These footprints are determined by the technology or processes used to transform our factors--labor and capital--into brown or green output. For example, if we take the case of agriculture, we could think of how much land is used (for example, whether it leads to deforestation) and whether organic (greener) or non-organic (browner) methods are applied to grow crops. Or we can consider how much carbon is emitted in the energy sector and its adverse impact on the environment.

Given our linearity assumption, the slope of each environmental efficiency curve is constant, signified by α_i, where the sector i will be G for green and B for brown (see chart 2).

Chart 2

Environmental efficiency curves: From economic output to environmental impact



Source: S&P Global Ratings.

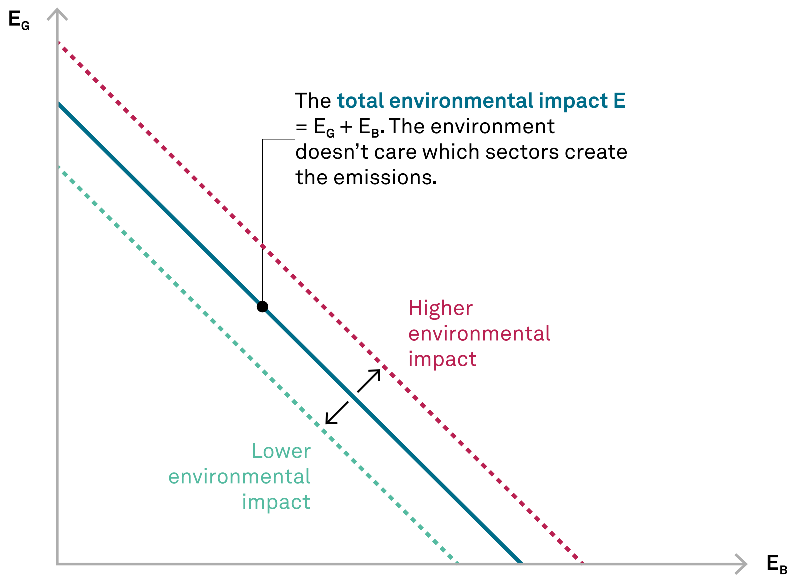
In line with the identification of our two sectors, we assume that $\alpha_G < \alpha_B$. By assumption, the negative environmental impact of any amount of green output is always lower than that for the same level of brown output. Like the PPF, these curves (lines) will shift to reflect changes in technology. An innovation that reduces the adverse environmental impact of a sector (i) will lower α_i and rotate the curve downward (toward the horizontal axis), showing that the environmental impact falls for every level of output. For example, capturing methane emissions from oil production will move the α_B curve (corresponding to brown output) downward.

Using these curves, the environmental impact of output in both sectors can be derived once we know our equilibrium level of output from the PPF. For the green sector, it is $\alpha_G G'$, where G' is the equilibrium output of green goods from the PPF in our two-sector model in chart 1. Analogously, the environmental impact of brown-sector output is $\alpha_B B'$, where B' is the equilibrium output of the brown sector from the PPF. Note that, in chart 2, output is shown on the horizontal axis and the environmental impact units are on the vertical axis.

Deriving the total environmental impact. We can now obtain a total adverse environmental impact for the economy. Namely, the environmental impact (E) is simply the sum of the two sectoral impacts: $E = E_G + E_B = \alpha_G G + \alpha_B B$ (see chart 3).

Chart 3

Total environmental impact



Source: S&P Global Ratings.

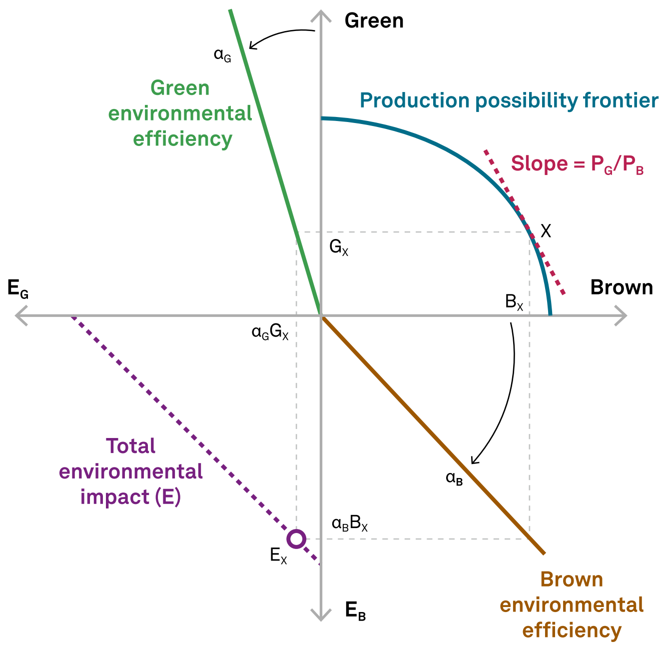
This linear relationship between E_G and E_B means that the environmental impacts of the two sectors' outputs are perfect substitutes. We just add them up since they are measured in the same units. This linearity of the total environmental impact across sectors means that any degradation of the environment (from say a unit of emissions) is the same, regardless of which sector it comes from. In this simple model, we ignore potential tipping points (such as deforestation of the Amazon rainforest or the local dynamics of biomes). The further outward an E line is from the origin, the higher the adverse environmental impact of production from the corresponding PPF, and vice versa. This underscores the natural tension between increasing output and protecting the environment.

Applying The Model: Finding "Environmental Equilibrium"

We are now in a position to put everything together and show the equilibrium output for the economy in our model and its corresponding environmental impact. All variables are simultaneously determined. We can illustrate this by using a familiar four-quadrant representation (see chart 4):

Chart 4

Equilibrium output and the environmental impact



Source: S&P Global Ratings.

The quadrants explained:

Northeast quadrant: Composition of output

- The PPF shows the equilibrium output for the green and brown sectors. These output levels are determined by the relative price line P_G/P_B showing the price of green goods in terms of brown goods. (To keep the chart tidy, we have omitted the indifference curve that determines this relative price ratio.)

Northwest and southeast quadrants: Translating goods output into its environmental impact

- The green environmental efficiency curve in the northwest and brown environmental efficiency curve in the southeast quadrant generate the change of units and translate goods production into their environmental impact. Note that the slopes of these curves are measured in relation to the upper vertical axis and right horizontal axis, respectively.

Southwest quadrant: Total environmental impact from the economy's output this period

- The total environmental impact in the southwest quadrant shows as the sum of the impact from the two sectors. The environmental impact of the equilibrium output is only one point on this line, denoted as E_X. The line represents a range of points, along which the total environmental impacts are equal, corresponding to a continuum of economic outputs, each associated with a different PPF.

Interpreting The Results: A Deep Dive Using Comparative Statics

With the framework for analyzing economic output and environmental trade-offs in place, we can now examine the potential consequences of changes in key variables in our model. We do this through comparative statics, that is, by changing one variable at a time and seeing what happens. A more formal and complete model would contain optimization techniques that let all variables interact.

The goal here is to explore the impact of changes in a context where economic growth and the environmental impact are at odds. The results throw some well-established results of growth theory into question.

1. Green-biased relative price changes reduce the negative environmental impact

Externalities refer to the costs or benefits of output that are not incurred or received by the producer; and their omission from market prices is well known. In cases where production carries negative externalities--such as land degradation, carbon emissions, or pollution more generally--market prices for the produced goods or services are too low from an environmental perspective. This is because the private costs of production (costs internal to the producer) do not fully capture the negative externalities, leading to the overproduction of goods relative to the environmental optimum.

The classical policy response to correct the effect of negative externalities is to impose a tax on the polluting good. This Pigouvian tax (named after a British economist) is equal to the difference between the private cost of producing that good and the related cost to society. In more recent times, this can be thought of as putting a price on nature. The idea is that such a tax forces the producer to internalize the externality, which moves output to its environmentally optimal level. Note that this argument does not consider the environmental impact of output in the same way as the model in this paper. Not surprisingly, such a tax serves to reduce output of the taxed good.

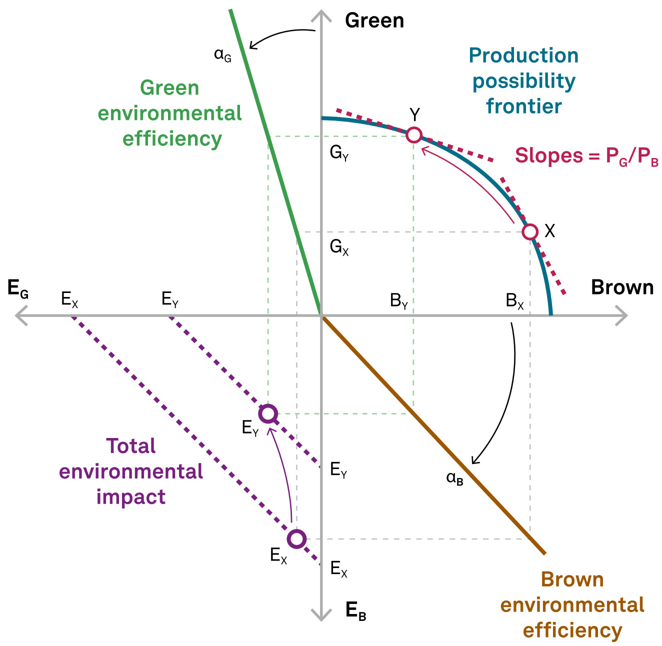
In our model, we examine the effect of a tax on output from the brown sector. In the case of carbon emissions, examples of such taxes already exist, with carbon pricing and carbon taxes covering around 23% of global emissions (see "Carbon Pricing, In Various Forms, Is Likely To Spread In The Move To Net Zero," published Aug. 9, 2022, on spglobal.com).

The impact in the model is the same: A tax raises the relative price of producing brown goods relative to green goods. As a result, brown output and consumption fall, while green output and consumption rise. Note that this example is for expository purposes and does not imply the production of all green goods is free of negative environmental externalities.

The result of imposing a tax on brown output is a reduction of the total environmental impact (see chart 5; the move to point Y from point X in the northeast quadrant). Green output is clearly higher and brown output is clearly lower. And given our assumptions about the intensity of environmental impact of these sectors, the total environmental impact will decrease to E_X from E_Y, shifting the E line (southwest quadrant) toward the origin. The larger the tax, the bigger the reduction of the harmful environmental impact, although we should keep in mind that the objective of the tax is to equate private and social costs of production, not to minimize the adverse impact on the environment. That would require reducing brown-sector output to zero.

Chart 5

Effects of an environmental impact tax



Source: S&P Global Ratings.

Such an outcome would not maximize the welfare of consumers as long as they wish to consume some amount of brown goods or services. Relatedly, this would not be consistent with our assumptions for the indifference curve, namely that there is some complementarity for consumers between the outputs of the green and brown sectors. For example, we need energy to produce critical goods such as steel, cement, plastics, and ammonia, as argued forcefully in "How The World Really Works" (Vaclav Smil, 2022).

Although we focus here on the impact of an environmental tax on a static equilibrium, we also note that such a tax would likely trigger second-order effects. Over time, a tax--assuming it is credibly maintained--should give firms more incentives to improve efficiency to reduce the environmental costs of production and respond to consumers' demand for greener goods. This is a visible result of carbon pricing policies in the EU, for example.

However, other factors may result in relative price changes. In our example, the price change stemmed from the imposition of a tax that would have induced the producer to internalize the externality, that is, take it into account in decision-making and pricing the full impact of production on the environment. Another possible solution is to have individual agents, including consumers and investors, internalize the externality through some combination of regulation and education. For instance, this could include bans of fossil fuel cars; central bank climate stress testing; initiatives that can affect consumer preferences, such as by building awareness about the environmental footprint of consumption patterns; or subsidies for cleaner technologies, as in the U.S. Inflation Reduction Act.

In sum, to lead producers to fully incorporate negative externalities, the necessary relative price change will likely come through a mix of preferences and policy. The effect on output will be the same. In our model, the impact of the hypothetical policy-led environmental tax on the interaction of output and the environment accords well with a widely held view in economics literature: "tax the bad stuff."

But what could happen to the environment when there is factor accumulation, in particular relating to the demographic dividend, where economic-growth potential shifts alongside changes in a population's age structure? We look at that next.

2. Increasing the amount of available resources has a negative environmental impact

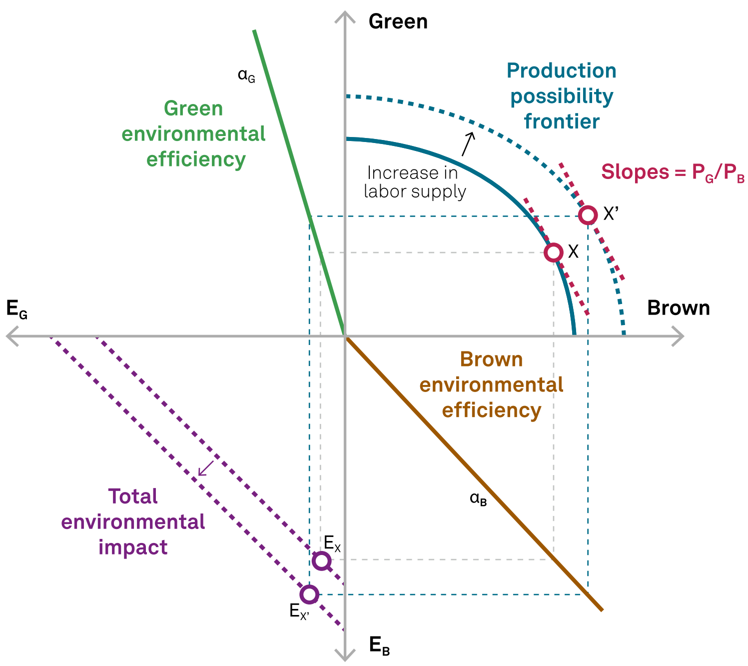
Models of economic growth are based on the accumulation of factors (or inputs) of production, such as labor, land, and forms of capital. This established, unambiguously positive, relationship between resource accumulation and well-being is more complicated when we add the environmental impact of economic activity.

In fact, it can be in reverse. Any increase in output, including from higher amounts of capital or labor, raises both output and the associated adverse environmental impact. Output is often viewed in the economics field as a positive outcome, while incorporating the environmental impact of that output could be either positive or negative for consumers' well-being.

In our model, a higher amount of labor or capital pushes out the PPF curve, generating more production. However, it simultaneously increases E, worsening the environmental impact (see chart 6). And the more skewed the increase in output is toward the brown sector, the larger the movement of E away from the origin, implying greater harm to the environment.

Chart 6

Increase in output from factor accumulation



Source: S&P Global Ratings.

This result turns well-entrenched notions about the benefits of growth on their head, at least when viewed through an environmental lens. A specific example is the demographic dividend. Here, the idea is that a high birthrate will eventually increase the labor force and human capital, thereby allowing for faster growth than in economies with lower birthrates. Output will rise, and so should prosperity. While the demographic dividend still holds true in the narrow economic sense, the overall benefit is now clouded--if not neutralized--by the negative impact on the environment.

A definitive view on the influence on overall well-being would require introducing into our model the preferences of consumers regarding the environment, not just the consumption of green and brown goods/services. This addition--which is beyond the scope of this paper--would specify the trade-off between higher consumption linked to higher output, and a greater negative environmental impact (denoted by E in our model) resulting from that higher output. Note that consumer preferences, combined with a wider range of goods and services and a better environmental outcome, are likely to vary across economies at different points in their development process. A common assertion is that agents in higher-income economies put greater weight on positive environmental outcomes.

When the population and human capital are declining, output will likely decline as well, all else constant. It's important to note that, in certain economies with such demographics (like Japan), per capita output and therefore real incomes can still increase. The decline in output means that the environmental impact of activity is also falling. This could lead to welfare gains even if output is lower, again depending on consumer preferences. Perhaps the dreaded prospect of population declines in Europe and other economies isn't that negative after all, at least from an environmental sustainability standpoint.

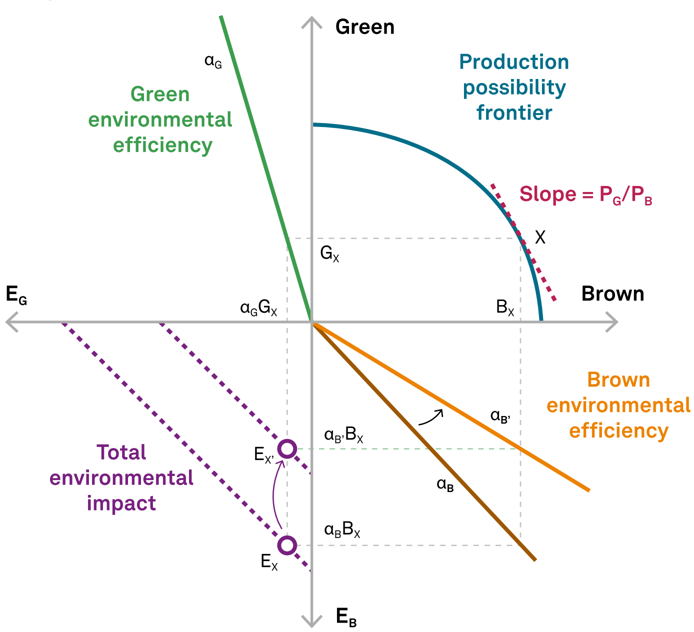
3. Improving environmental efficiency is typically a desirable outcome

Another important parameter that shifts in our model is the environmental efficiency of production. It should come as no surprise that improving environmental efficiency, such as by lowering emissions, is beneficial. This is true for both green and brown output. For a given level of output, the lower the efficiency curve (α_G or α_B), the lower the detrimental impact on the environment. As long as consumers care about the environment, this positive outcome will be true.

For example, a more environmentally efficient brown sector means that the α_B line rotates toward the x-axis (see chart 7), which measures the output of that sector. This implies that, for any level of brown output, the environmental impact is lower.

Chart 7

Improving environmental efficiency



Source: S&P Global Ratings.

Our model shows that when α_B improves, the economy-wide environmental impact (E) declines. Importantly, all of this gain comes from the B sector, so E_B falls while E_G remains constant. The economy-wide environmental impact therefore moves parallel to the E_B axis, shown in the chart moving to $E_{X'}$ from E_X. The extent of the environmental gain from the innovation in the brown sector will depend on the relative output of the brown sector to that of the green sector. The larger the share of brown output from innovation, the larger the gain.

The change in α_B is akin to what happens when firms change their production processes to reduce their environmental impact. Examples include farms moving to organic production methods or vertical farming, or carbon capture in industrial processes. Note that, in this scenario, the output of the economy does not change since we still have the same amounts of labor and capital and the same technology to convert those inputs into output. But, critically, the environmental impact of that unchanged output has declined. In this light, going from brown to "beige" (a less negative environmental impact than brown) might be as important as going green.

Applying this finding to the context of carbon emissions suggests that just reducing the carbon footprint of high emitters (like the iron and steel industry) can be a way to reduce total emissions in the short to medium term. This is because it would take time to move to a greener point on the PPF, given the need to develop and roll out environmentally friendly technologies. For example, the introduction of renewables is helping the power sector reduce its total emissions.

But the transition away from fossil fuels cannot happen without enough installed renewable energy capacity to meet total energy demand. This is also why energy sources such as gas have been identified as a way to bridge the gap to zero emissions in the power sector. Other innovations, such as the use of 3D printers to reduce the amount of concrete needed for construction, can help as well.

Innovation's Role In Green Growth

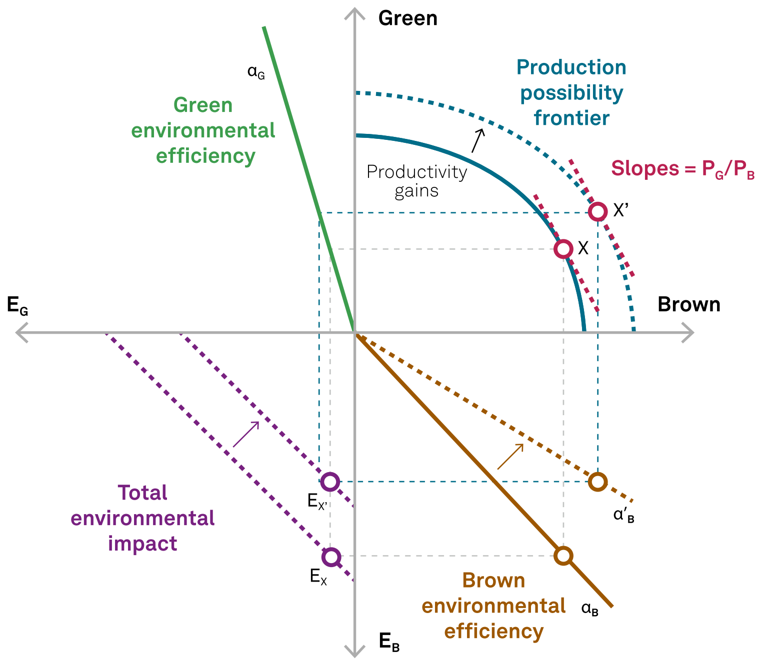
The results of our model so far suggest that achieving green growth--where output expands but the environmental impact does not--may be problematic. But this is because the position that more is generally better, and efficiency gains are always possible, does not hold when the environmental impact is thrown into the mix. Indeed, focusing on the environmental impact seems to suggest that economic activity may need to be lower than it currently is, or leapfrog innovation must take place to arrest the ongoing deterioration of the environment. That said, in our simple model, we have so far changed only one variable at a time. We believe allowing for multiple moving parts will show the way toward a possible, greener growth future.

The clearest way to see this potentially beneficial outcome is through green innovation. Imagine an innovation that shifts the PPF curve outward in the northeast quadrant and, at the same time, rotates one or both of the efficiency curves inward.

A good example might be moving from a combustion engine car to an electric car. The harmful effect on the environment from electric vehicles is lower than that from combustion vehicles (measured over the entire life cycle), which rotates the efficiency curves inward (see chart 8). In our model, the productivity increase from innovation (electric motor) pushes the PPF outward and production and consumption move to point X’ from point X. At the same time, reducing the adverse environmental impact of brown output (car production) lowers α_B and moves the corresponding environmental efficiency line upward. The combined result is higher output and a less damaging environmental impact than before the innovation. This is an example of green growth, assuming that innovation occurs repeatedly over a period of time and is not a one-off event.

Chart 8

Green growth that reduces the environmental impact



Source: S&P Global Ratings.

Indeed, one round of discrete shifts does not clear a path to economic sustainability. Yet there is cause for cautious optimism. Examples of continuous innovation include rising agricultural yields in developing countries and the ongoing development of renewable electricity generation that has seen a steep decline in the associated costs over the past few decades, making renewables a more competitive alternative to fossil fuels.

Rethinking Productivity Growth Using A Green Lens

Increasing productivity has traditionally been linked to innovations to combine inputs (labor and capital) more efficiently to produce a given level of output. Steamboats, for example, reduced the need for labor to propel ships. Fertilizers increased the output of crops on the same land with the same equipment and lower labor input. Computers have enhanced our lives in unimaginable ways, with far fewer inputs (components) than previously. All of these would shift the PPF outward in our model.

But when we include the environmental impact, this view of innovation seems incomplete. Some innovations may not shift out the PPF but could lessen the negative environmental impact of the existing level of activity, examples include carbon or methane capture for industrial processes. Others may increase output but not reduce the harm to the environment. Some innovations, like electric cars, do both.

Added to this, innovation dynamics are a bit more complex than represented here and tend to follow S-curves, where the pace of growth changes over time. In other words, while some green technologies might be very costly at the start, they can take off rapidly once a certain market size is achieved, operating at scale. Electric cars are a good example. Although they were relatively costly at the beginning, they now provide an increasingly viable substitute to fossil fuel cars.

This all points to the need for further efforts to broaden our understanding of the scope of productivity gains. A green growth mindset requires us to measure and evaluate both the economic and environmental impact. Focusing on productivity-enhancing innovations only is no longer sufficient.

Gauging Environmental Sustainability

So far, we have explored economic activity (output) in a period of time and the negative environmental impact of that activity. These two variables are inversely related, but we showed in our model that green growth is possible under certain circumstances. What we now attempt to determine is whether an amount of E (environmental impact) generated by economic activity is sustainable or not.

To do this, we need a sustainability target. In its simplest form, this can be a static target where the net environmental impact of economic activity is zero. A more complicated and perhaps relatable target would be a path toward zero greenhouse gas emissions, taking place over a prescribed period of time. We currently have many commitments of this sort by governments and corporations, usually decades away.

Sticking with the simple version, let's call the point of zero net environmental impact, E*. To derive E*, we have to look at how much E a level of economic activity generates as well as any offsetting factors. These offsets include natural processes of regeneration and man-made innovations such as general carbon capture (not linked to a specific production process) or rewilding.

Regeneration of the environment.

- Central to thinking about sustainability is the observation that the environment has regenerative properties. The environment can repair itself, at least partially. If all economic activity were to cease, we imagine the physical environment would eventually revert to its pristine state, as long as we have not reached a point of no return. We saw some evidence of this during the pandemic, when wildlife returned to urban areas during lockdowns, including in New York city, where birding became a popular pastime. Let's call this natural regeneration factor, R^N.

Man-made offsets.

- Man-made offsets exist as well, and their prevalence is increasing as environmental awareness rises and economic incentives are put in place. A prime example of man-made offsets includes technologies that can remove or capture pollutants from the environment, such as carbon capture schemes like the Orka project started in Iceland in 2021. Another type of effort that does not involve technological advances is rewilding, or intentionally allowing the environment to regain some of its natural carbon-absorptive capacity. Let's call these types of man-made impacts, R^M.

If we assume that these two types of offsets are additive, then we can arrive at a simple definition of E*; namely, the level of environmental impact from production, where $E^* = R^N + R^M$.

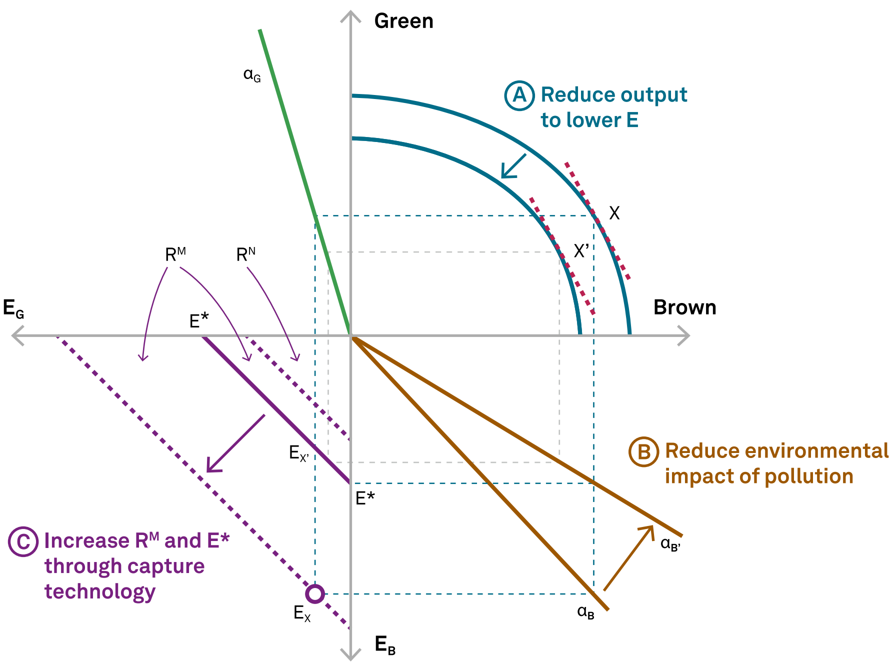
Getting to E*

In our model, there are three ways to achieve a net zero environmental impact, E*, starting from a situation that is not sustainable, that is, where E > E* (see chart 9):

- First, and least desirable, output can fall (Case A). This involves an inward shift of the PPF in the northeast quadrant so that E falls to its sustainable rate in the southwest quadrant. This will involve a decline in output (and consumption) in both the green and brown sectors.
- Second, an innovation in production in one or both sectors can reduce E to its sustainable rate without a decrease in output (Case B). In the chart, we show a reduction in α_B that lowers the environmental impact of producing brown output, which lowers the overall environmental impact to E*.
- Third, rather than bring down E, we can raise E* (Case C). For example, the increased use of carbon capture technology can increase R^M. This, in turn, will allow an increase of the gross positive environmental impact on the economy, while still achieving sustainability. Here, the E* line shifts outward and equalizes with the original E line, which becomes the new E* line.

Chart 9

Environmentally sustainable equilibrium: Achieved three possible ways (A, B, or C)



Source: S&P Global Ratings.

As with our comparative static exercise earlier, various combinations of these three pathways, acting simultaneously, are compatible with environmental sustainability in our model.

Looking Ahead: Paths To Progress

The trade-offs between economic activity and the environment have been absent from most growth models. That is because the negative environmental impact of activity is largely external to producers and consequently not priced. That is now changing as awareness rises about the environmental impact of economic growth. But the road to sustainability may be long. The Paris Agreement and updates of emissions targets in subsequent conventions on climate change indicate that sustainable economic growth is still some way off, if it can be achieved at all.

We agree with the challenge of attaining green growth, but not with the pessimism. In this paper, we have developed a framework to help highlight the trade-offs and map out the paths of potential progress. The structure of our model illustrates that the pursuit of economic growth does not automatically translate into economic prosperity once we take into account the environmental impact.

We believe that continuous innovation, rather than reining in output, is the best way to minimize the adverse impact of economic activity on the environment. This innovation would involve not only making the economy more productive (the traditional goal) but also shrinking the environmental footprint of production. We already see this with the growth of renewable energy generation as well as the decarbonization of economic sectors. Last but not least, getting to green growth requires a full accounting of the environmental impact of production. This, in turn, should lead policymakers and markets toward a pricing structure that guides spending and production onto a path where growth is both efficient and sustainable.

Related Research

- Carbon Pricing, In Various Forms, Is Likely To Spread In The Move To Net Zero, Aug. 9, 2022
- Natural Capital and Biodiversity: Reinforcing Nature as an Asset, April 22, 2021

External Research

- How The World Really Works, Vaclav Smil (2022)
- Finance and Development: The Scramble for Energy, International Monetary Fund (2022)
- The Economics of Biodiversity: The Dasgupta Review, HM Treasury (2021)
- Global Future Council on the Future of the Energy Transition, World Economic Forum
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