Going Beyond GDP:

The Swiss Green Domestic Product

E4S White Paper
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Enterprise for Society (E4S) is a joint venture of the University of Lausanne through its Faculty of Business and Economics (UNIL-HEC), the Institute for Management Development (IMD) and the Ecole polytechnique fédérale de Lausanne (EPFL), under the stewardship of its College of Management of Technology, with the mission of spearheading the transition towards a more resilient, sustainable and inclusive economy. E4S is committed to training the next generation of leaders, inspiring economic and social transformation, and promoting change by strengthening start-ups and boosting innovation.

The project was conducted in the context of a partnership with Fondation Leenaards.

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SUMMARY

What is new?

We propose a novel indicator, the Green Domestic Product (GrDP) to remedy some of the shortcomings of GDP. The GrDP extends the scope of the GDP to integrate the depletion of natural, social, and human capital. Concretely, GrDP is defined as GDP minus the external costs associated with the production of goods and services, including the impacts of the emissions of greenhouse gases (GHG), air pollutants, and heavy metals.

Why does it matter?

Our decisions are influenced by what we know and by what we measure. Flawed measurements can lead to distorted decisions. By considering the economic, environmental, and social dimensions, GrDP allows us to make more informed and sustainable policy decisions, and to move beyond the dichotomy between promoting economic growth and protecting the environment.

What do we learn?

In Switzerland, the gap between GrDP and GDP is narrowing, the economy is growing while air pollution is decreasing. Still, external costs remain significant, about CHF 25.3 billion or 3.5% of GDP in 2019. Air pollutants and GHG both have important environmental and social impacts. However, while economic growth and air pollutant emissions are successfully decoupling, decarbonisation remains too slow. There are opportunities for the future: many decarbonisation levers have significant co-benefits by also reducing air pollutant emissions and thus enhancing GrDP growth.

THE RISE AND FALL OF GDP: ALL HAIL THE GRDP!

The Gross Domestic Product (GDP) is a valuable indicator measuring the monetary value of all goods and services produced in a country within a given time period. However, the GDP is not and never was an indicator of economic performance and social progress. Already in 1934, Simon Kuznets, who invented the Gross National Product (GNP) – GDP's predecessor, warned that national income statistics do not measure welfare. Indeed, while economic science is interested in properly managing all resources, the GDP does not encompass the indirect impacts of productive activities such as environmental pollution. Thus, the GDP is not a good measure of the value effectively created because it fails to account for the depletion of natural, social, and human capital associated with economic activities.

Today, the climate crisis requires urgent action to decarbonise our society. However, there is often a perceived dichotomy between promoting economic growth and protecting environmental sustainability. But these two objectives need not be conflicting, as stated in 2009 by the Stiglitz-Sen-Fitoussi Commission:

> *"What we measure affects what we do; and if our measurements are flawed, decisions may be distorted. Choices between promoting GDP and protecting the environment may be false choices, once environmental degradation is appropriately included in our measurement of economic performance. So too, we often draw inferences about what are good policies by looking at what policies have promoted economic growth; but if our metrics of performance are flawed, so too may be the inferences that we draw."*
>
> Stiglitz, Sen, Fitoussi et al., 2009. Report by the Commission on the Measurement of Economic Performance and Social Progress. p7

In this paper, we propose a novel indicator, the Green Domestic Product (GrDP), to remedy some of the shortcomings of GDP. The GrDP is calculated by subtracting the external costs associated with producing goods and services from the standard measurement of GDP. This new measure was initially proposed by Danthine et al. (2020) in the E4S white paper Green Domestic Product: Netting Greenhouse Gas Emissions from Gross Domestic Product. We go one step further by extending the scope of GrDP to the emissions of air pollutants and heavy metals in addition to the one of greenhouse gases (GHG). The impacts covered include climate change, health issues, decrease in crops' yields and biomass production, buildings degradation, and damages to ecosystems due to eutrophication. A detailed description of the method used, data sources, and assumptions is available in the report *Green Domestic Product: Methodology*[1].

We present in this paper an application of the GrDP framework to the case study of Switzerland to demonstrate how GrDP can help understand the true costs and benefits of industrial activity. We first compare the evolution of GDP, GrDP, and external costs. We then explore the decoupling between economic growth and environmental pollution before proposing actions to leverage the co-benefits of decarbonation. We conclude by discussing the limitations of the GrDP in its current version.

1 Paper available here.

![E4S Enterprise for Society]

EXTERNAL COSTS ARE DECREASING BUT REMAIN SIGNIFICANT

Between 1990 and 2019, the Swiss GDP is upward trending – except in 2009 due to the economic crisis. GrDP follows the same trajectory but is significantly lower than GDP, as illustrated in **Figure 1** that represents the evolution of real GDP and GrDP. During the reporting period, GrDP is on average 7.6% lower than GDP in the central scenario.[2]

Fortunately, the external costs with respect to GDP are decreasing over time, as seen in **Figure 2**. Still, in 2019, the external costs were not negligible, accounting for approximately CHF 25.3 billion or 3.5% of GDP for that year. This is a conservative estimation for two reasons. First, the central scenario assumes that the current Swiss carbon levy (120 CHF/tCO_2e) would be sufficient to reach net zero in 2050. If we fail to achieve this target, the climate change impacts could dramatically increase. For example, the total external costs in 2019 are almost twice as big in the high carbon price scenario compared to the central scenario. Second, the current scope of the GrDP only includes the external costs of greenhouse gases (GHG), air pollutants, and heavy metals, i.e., pollutants for which the impacts are known, measured, and priced. As a comparison, the Swiss Federal Office for Spatial Development (ARE) estimated that the external costs of transport were 14 bn. in 2019, also accounting for impacts out of the scope of our study such as noise (2.8 bn.), nature and landscape destruction (1.2 bn.), and accidents (1.7 bn.) (ARE, 2022).

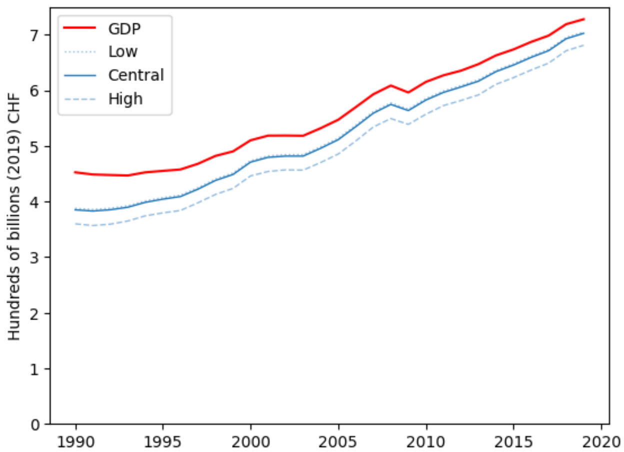

Figure 1: Evolution of GDP and GrDP

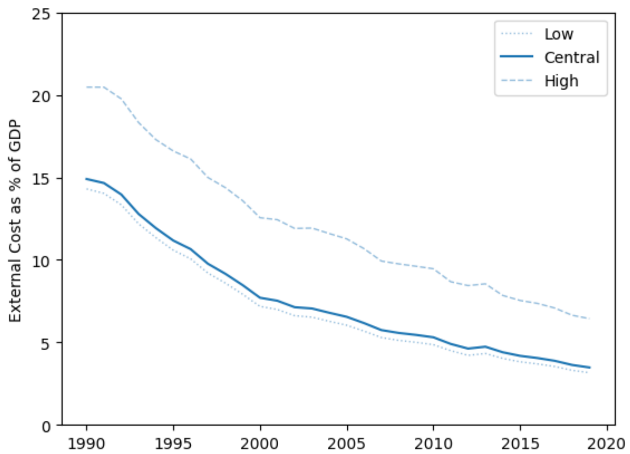

Figure 2: Evolution of external costs in percentage of GDP

Figure 3 presents the share of specific pollutant cost relative to the total cost. Air pollutants account for the majority of the external costs due to their large impacts on human health, starting with nitrogen oxides (NO_x). NO_x are mainly emitted through burning fuel, a prominent example being diesel vehicles. Some respiratory health issues may be exacerbated by inhaling this pollutant. It is also one of the most reactive air pollutants, which interacts with water and oxygen causing acid rain (EPA, 2022).

2 The low, central, and high scenario represents different assumptions regarding the damage cost of GHG emissions, namely 70, 120, and 583 CHF/tCO_2e. See the technical report explaining the methodology behind GrDP calculations for more information.

The share of GHG has been increasing since the 2000s. Carbon dioxide (CO_2) is the biggest contributor to climate change. Although CO_2 absorbs less heat than other GHG, the pollutant is much more abundant and long-live than methane or nitrous oxide (Lindsey, 2020). Additionally, carbon dioxide also acidifies the ocean, a phenomenon observed since the start of the Industrial Revolution, which inhibits marine life to extract calcium needed to build shells and skeletons (ibid.).

On the bright side, the external costs due to the emissions of heavy metal decreased significantly, and even reached levels close to zero since early 2000. This is in line with the implementation of the 1998 Aarhus Protocol on Heavy Metals which came into effect in 2003. This protocol specifically targets the reduction of emissions related to cadmium, lead and mercury stemming mainly from combustion (e.g., waste incineration) and industrial processes (UNECE, 2012). The spread of unleaded gasoline during the 1990s also explains this reduction.

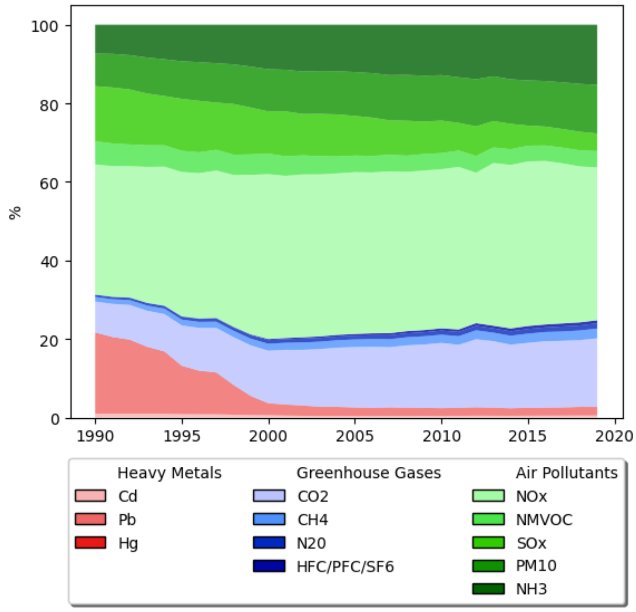

Figure 3: Evolution of the share of pollutant costs

CAN WE DECOUPLE ECONOMIC GROWTH AND ENVIRONMENTAL POLLUTION?

Figures 1 and 2 showed that the gap between GrDP and GDP is narrowing: the emissions of air pollutants are decreasing while the economy continues growing. We explore in this section whether Switzerland is decoupling fast enough, i.e., experience economic growth without increasing the pressure on environmental resources.

Growth rates are crucial for economists that aim to understand economic performance. If the growth of GDP is forecasted to be positive and even greater than the one of the previous periods that is usually good news – more growth means greater economic activity, greater tax gains and potentially more provision of public goods such as health care or child support and other economic and welfare gains. Given that GDP growth rates are a signal to assess an economy's overall health, the greater this growth rate the better (not too large, though) as negative growth rates are usually signs of an economic recession. In advanced economies, GDP growth rate has been relatively low. The Swiss economy grew only around 0.4% in the first quarter of 2022, and within the context of the Covid-19 pandemic recovery, new Chinese lockdowns, and the war in Ukraine "high uncertainties persist" according to Ronald Indergand, an economist at the State Secretariat for Economic Affairs (SECO) (Revill, 2022).

In the GrDP framework, growth can be pervasive: air pollution has often been considered to be the necessary evil to become more productive and studies associate GDP growth to GHG emissions (Ajmi et al., 2015; Marjanović et al., 2016). Reciprocally, too much pollution can impact productivity and welfare through (potential) lost days of work due to illnesses related to pollution or even premature deaths. In **Figure 4**, we compare the evolution of GDP and GrDP growth rates. In Switzerland, GrDP growth rate is exceeding that of GDP. However, during the last 10 years, the growth rates are closely matching, which suggests that although the economy is growing, external costs stemming from air pollution stabilised.

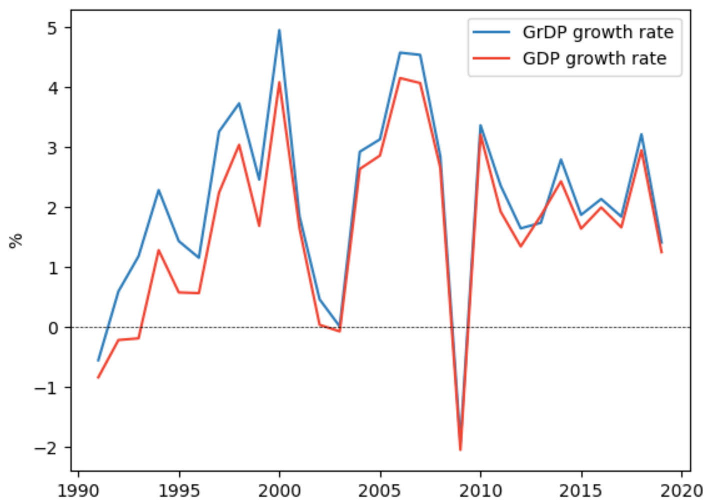

Figure 4 : Growth rates of GDP and GrDP, 1990-2019

Consequently, the rate of decoupling is slowing down. To determine the degree of decoupling we follow the inverse Tapio Decoupling Model (Shang & Luo, 2021; Xie et al., 2020) and compute the so-called decoupling factor D_t, which can be seen on **Figure 5**.[3] If the factor is equal to one then we are dealing with full decoupling, zero when we cannot observe any decoupling, and negative when there is coupling. Air pollutants and heavy metal pollutants show a comparatively high degree of decoupling from 2000 – the reference year. Heavy metals' factor reaches up to 0.7 and air pollutants' up to 0.6. Conversely, GHGs' decoupling factor reaches only 0.4, meaning that GHG emissions are still very much in line with economic growth. More concretely this means that one Swiss franc of GDP output cost 40% less in terms of GHG emissions in 2019 than in 2000.

However, so far we only considered the territorial emissions of GHG, reported according to the National Emission Inventory. Put differently,, the emissions generated by the production of imported goods and services were not included in the analysis. Since the GHG footprint emissions are about 2.7 times larger than the domestic

3 Dt = 1 - ((Et/Yt)/(E0/Y0)), with E the emission of pollutants (or external costs) and Y the GDP.

emissions in 2019, one might ask if this moderate decoupling of GHG was only due to a transfer of emissions from Switzerland to other countries.[4] It appears not to be the case. The decoupling factor of GHG footprint follows the same trajectory as the one of domestic emissions. Still, the speed of decarbonation is currently not sufficient to fulfil the Paris Agreement goals. Indeed, achieving net zero in 2050 implies a decoupling factor close to one.[5] In the following section, we discuss whether we can "kill two issues with one stone", decreasing air pollution and GHG emissions simultaneously.

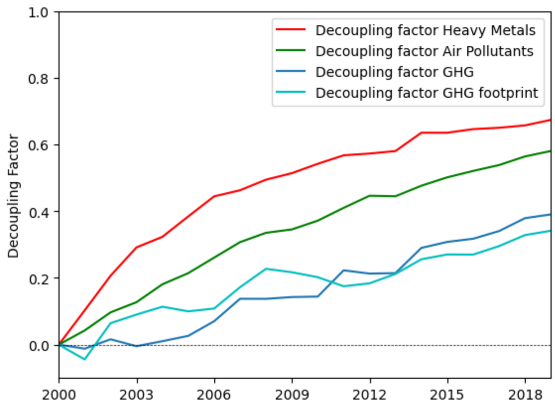

Figure 5: Decoupling factors (Reference: 2000)

LEVERAGING THE CO-BENEFITS OF DECARBONATION

To limit global warming to 1.5°C and avoid catastrophic consequences of climate change, GHG emissions must peak start decreasing by 2025, according to the latest Intergovernmental Panel on Climate Change (IPCC) report (IPCC, 2022). There is no unique pathway to meet the 1.5°C climate target and decarbonation, although necessary, should not come at the expense of exacerbating other environmental or social issues. For instance, can we decrease GHG and air pollutant emissions hand in hand? If so, GrDP would benefit from a "double-dividend" since the external costs of both GHG and pollutants would shrink. Ideally, climate actions would also stimulate economic growth, thus activating a third channel for GrDP gain.

Progress to render our systems more resilient has been observed across all sectors, but not all of them adopt risk curbing measures equally and large gaps between risk reduction and opportunity for transformation still exist. To analyse the origin of emissions in greater detail, we dive at the sectoral level, decomposing the emissions into seven categories: agriculture (includes forestry and fishery), industry, energy supply, transportation (includes information and communication), services, household heating, and household transportation.[6] **Figures 6 and 7**

4 GHG footprint is a reporting method that accounts for the emissions due to imports. See the E4S technical report on the methodology behind GrDP calculations for more information.

5 For a more detailed breakdown of the decoupling factors at the sectoral level, please refer to the Appendix.

6 We use the Air Emissions Accounts reporting, data from the Swiss Federal Statistical Office, since the dataset offers a more detailed granularity, distinguishing

represent the evolution of GHG and air pollutant emissions per sector since 2000. Air pollutant emissions have decreased in all sectors since 2000, even though the emissions due to transportation have increased again since 2009. As observed at the aggregated level, GHG emissions did not experience the same cutback, and the emissions of some sectors such as transportation and energy supply have even increased.

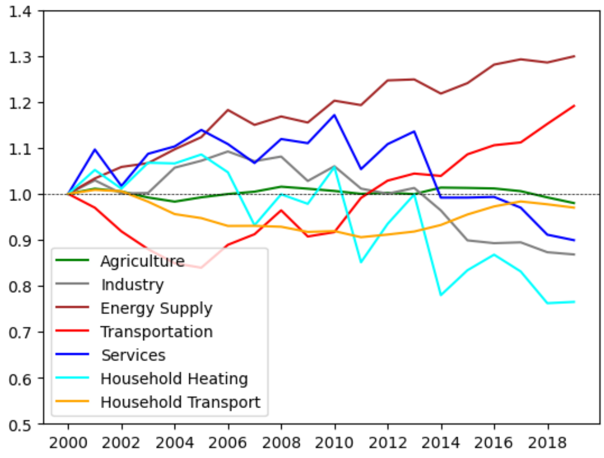

Figure 6: Evolution of GHG emission per sector (ref. 2000)

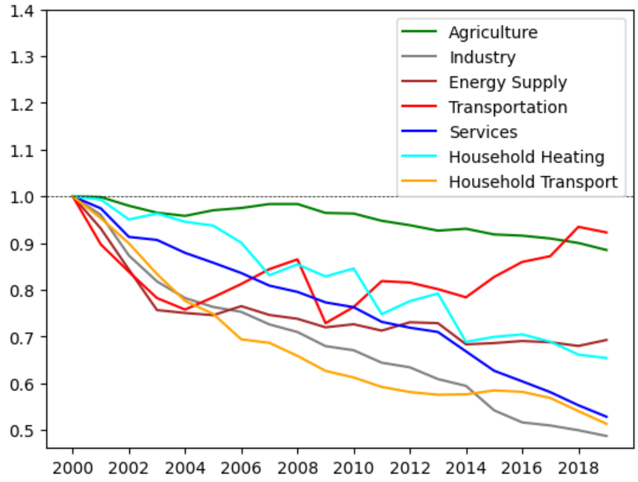

Figure 7: Evolution of air pollutant emission per sector (ref. 2000)

The moderate decrease of air pollutant emissions from agriculture can be traced to a reduction in nitrogen oxides (NO_x) emissions, which are generated by the application of nitrogen fertilisers. Fertilisers are also responsible for the emission of nitrous oxide (N_2O), a strong GHG. In our E4S white paper *Threats to Nitrogen Fertilizer, Opportunities to Cultivate Sustainable Practices?*, we discussed three strategies to limit the use of nitrogen fertilisers: increase nitrogen use efficiency, reduce food waste, and a shift towards less meat-intensive diets. In addition to reducing nitrogen-related pollution, the shift towards less meat-intensive diets would also limit the emissions of methane, a powerful GHG emitted by livestock.

Transport is the largest emitter of GHG in Switzerland – 31.6% of total emissions in 2020.[7] It is also one of the slowest to decarbonise, its emissions are stable since 1990. In **Figure 6**, transportation emissions are pushed through the activity level of freight transport – since 2007 goods transported by roades increased by 25%, which is reflected in the surge in information and communication technologies.[8] For household transportation, the gain in efficiency is offset by the increase in passenger activity level – between 2000 and 2019 passenger cars activity level increased by about 27%.[9] Electrifying transport systems with renewable-powered vehicles would contribute to reducing both GHGs and air pollutants such as fine particles PM_{10} that are produced by the combustion of fossil fuels. Another option to decarbonise transportation is to adopt synthetic fuels. These fuels are produced by hydrogen and captured CO_2, closing the carbon loop. They also have the advantage of using the same infrastructures as conventional fossil fuels. Thus, they could play a crucial role in reaching net

industrial and household activities. See the E4S technical report on the methodology behind GrDP calculations for more information.

7 See Greenhouse gas inventory, Federal Office for the Environment FOEN

8 See Goods transport, Federal Statistical Office FSO

9 See Passenger transport, Federal Statistical Office FSO

zero. However, synthetic fuels would not clean the air since air pollutants are still emitted by their combustion.

The increase in GHG emission in the energy supply sector is partly explained by the expansion of thermal power plants, which include gas and waste incineration plants.[10] The planned shutting-down of nuclear power plants by 2035 combined with the foreseen increase in electricity demand – e.g., due to the electrification of transport – will add pressure on the energy system. Still, a large deployment of renewables could allow net-zero emissions of GHG while shrinking air pollutant emissions.[11]

The annual variations in the emissions of services and household heating mimic the fluctuating energy consumption from one year to another: a harsher winter will result in additional "heating degree days", an indicator of the heating needs. The decline in emissions reflect the improving energy performance of buildings, e.g., through better insulation and an increase of renewables. Still, oil boilers remain the dominant heating system in Switzerland. Their replacement by renewables (e.g., heat pumps and solar thermal installations) would cut emissions of both GHG and air pollutants. By contrast, burning wood is carbon-neutral because the combustion releases the CO_2 captured by trees during their growth, but it does emit air pollutants such as fine particles.

To summarise, most but not all levers of decarbonation have significant co-benefits. Hence, decarbonation, when properly designed, could improve environmental and social conditions, and enhance GrDP growth.

THE GRDP IS NOT AN INDICATOR OF SUSTAINABILITY

The need to adjust indicators to guide policy decisions is crucial to achieving climate and sustainability goals. The GrDP indicator is thus a step in the right direction by accounting for the depletion of environmental, social, and human capital due to the emissions of GHG, air pollutants, and heavy metals. However, pursuing GrDP growth alone is not sufficient to achieve sustainable development for several reasons:

1. GrDP aggregates all the economic activities and externalities in one indicator. As GDP, it hides the heterogeneity of income within countries and does not inform about social inequalities.
2. Since the scope of GrDP is currently limited to the emissions of GHG, air pollutants, and heavy metals, the measure is far from accounting for all the external costs. For example, plastic pollution, environmental destruction (e.g., extending agricultural areas and building infrastructures at the expense of wetlands and forests), and water pollution are not considered.
3. GrDP can only account for the externalities that are known, measured, and valued. Thus, the scope of

10 See Energy statistics, Swiss Federal Office of Energy SFOE

11 For example, the Energy perspectives 2050+ scenarios develop energy systems compatible with net-zero GHG emissions by 2050. See Energy perspectives 2050+, SFOE

impacts is also limited. For instance, the damages to biodiversity only include eutrophication issues in protected areas.

4. Since the GrDP does not measure the exhaustion of resources such as minerals and materials, it would be possible to pursue GrDP growth without respecting the planetary boundaries.

Understanding the shortcomings of indicators is crucial to properly use them. The GrDP – albeit incomplete in its mission to value externalities – can be a helpful tool for policymakers allowing them to make more informed and sustainable policy decisions.

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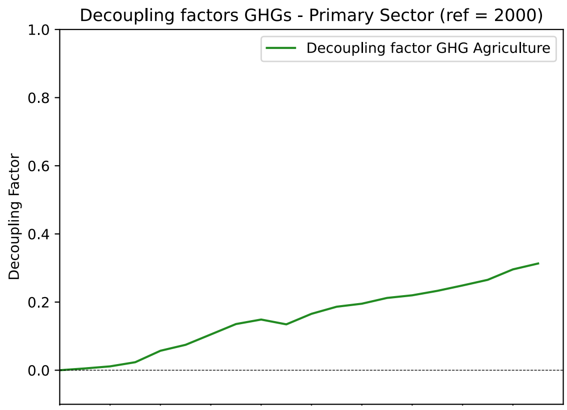
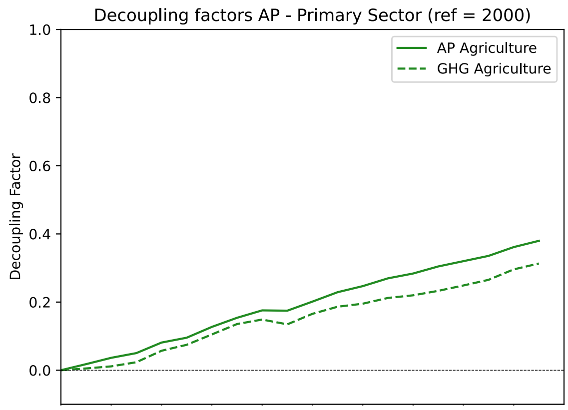
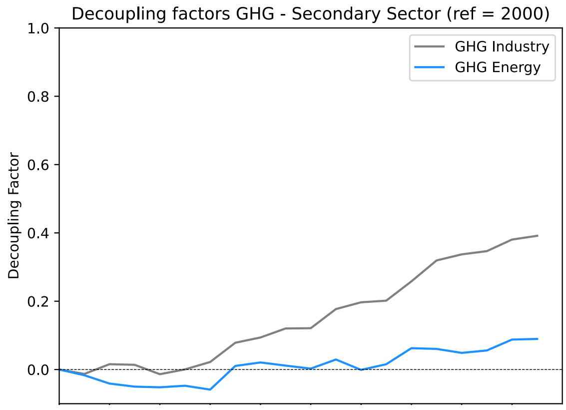
APPENDIX: SECTORAL DECOUPLING

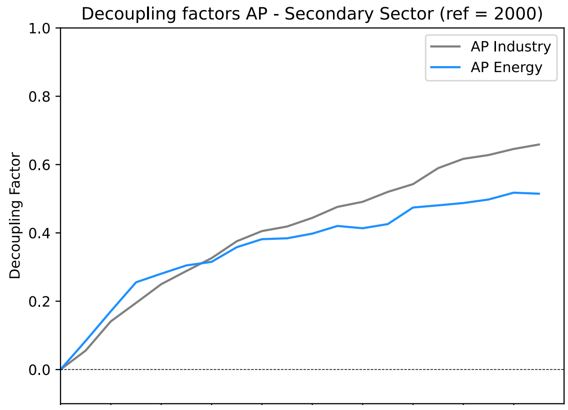
Primary sector



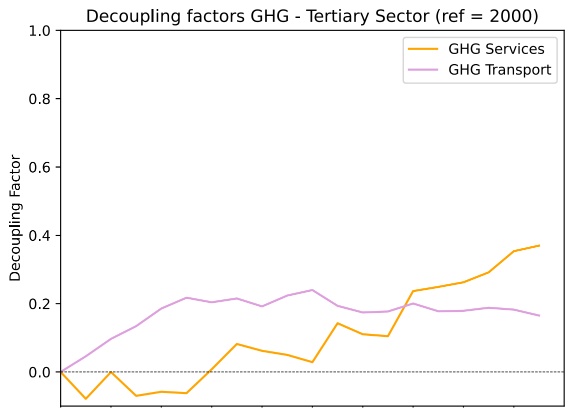


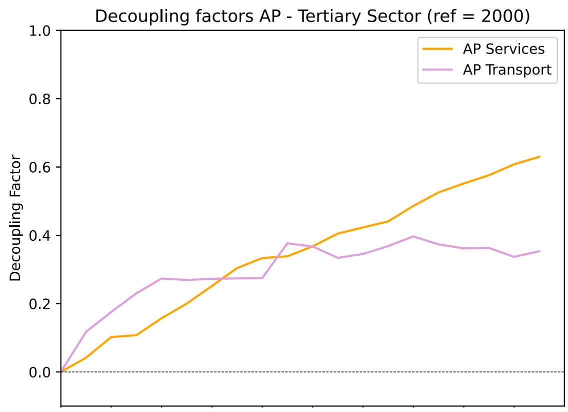
Secondary sector





Tertiary sector





Household activities