RESEARCH PROGRAM CH.DUPIN*

Collection of Historical Data on the Uses of Petroleum International Network

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April 2020

Abstract

This short note presents new time series on the consumption of oil at the country level since the 19^{th} century. In a context of extreme uncertainty and new challenges for the future of oil, understanding the link between economic activities and oil consumption over the long run is of paramount importance in order to derive realistic scenarios for climate change mitigation strategies. We show that the co-evolution of oil consumption and GDP has several regimes depending on the sub-periods considered. The publication of this database over a long period, associated with other historical sources, will allow researchers to feed the debate on energy-GDP decoupling with a historical vision.

Data are available at: www.longtermproductivity.com/chdupin

Click here for the latest version of the note

*We are indebted to Jean-Marie Martin Amouroux who has given us the authorization to publish this dataset that largely builds upon his hard work and years of collection. We also thank the company ENERDATA, which stored and kept safely these data for many years. We invite other researchers to amend or add new series to this database, which will be continuously monitored and updated.

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'The farther back you can look, the farther forward you are likely to see ."
— Winston Churchill

1 Introduction

The world is confronted with unprecedented challenges following the COVID-19 sanitary and economic crisis. This pandemic has and shall have huge macroeconomic impacts worldwide with 2020 witnessing a severe and global economic recession. According to IMF forecast, advanced economies should contract by 6.1% this year, and emerging economies by 1%. The subsequent ability of economies to rebound and compensate for this recession is still extremely uncertain.[1]

As during the 1970s or the 2008 crises, oil plays and will continue to play a central role to determine the length and magnitude of this economic depression (see Hamilton, 2009). Because the COVID-19 has temporarily haltered geographical mobility (due to "social distancing") within and across most countries, the short term response of oil consumption was a collapse in proportion never observed before (see e.g. Figure 1 for the US). Such movement is likely to amplify the effect of the current crisis by creating massive and long lasting disruptions in many sectors, markets and countries. At the same time, oil producers are trying to face this threat by resurrecting cartels at the international,[2] or at the national level[3] as oil prices have plummeted to a historically low level that was never seen for the past 18 years (Figure 2).

The current situation will have implications at different time horizon, highlighting the complex relationship between economic outcomes and movements in oil consumption. In the short term, the links and feedback between such a collapse and global and local economic growth are a key issue for economists and policy makers (see Lepetit, 2018).In the medium term, as capital expenditure (CAPEX) on production from new fields or enhanced recovery (depletion mitigation) from old fields is progressively declining, any future demand for oil resulting from a possible economic recovery, will face a tightening of oil supply. On the longer run, and perhaps more importantly, oil producers, whether they are countries or national and international Exploration and production Oil & Gas

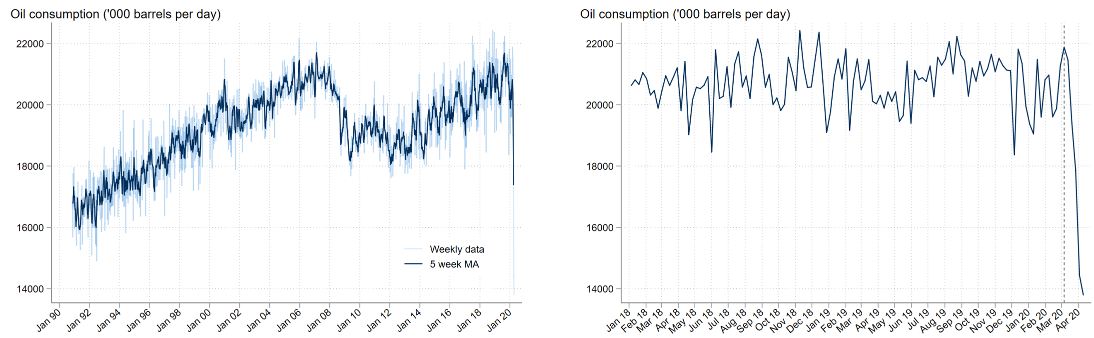
[1]See IMF World Economic Outlook of April 2020

[2]See the OPEP press release of April 12, 2020: *"On Thursday and Friday last week, we took the responsive and responsible action to focus on adjusting crude oil production by 10 mb/d beginning on 1 May 2020, for an initial period of two months; then by 8 mb/d from July to December 2020; and by 6 mb/d for the period of January 2021 to April 2022, in the interests of producers, consumers, and the global economy."*

[3]see e.g. Lepetit (2020)

Figure 1: Oil consumption in the US

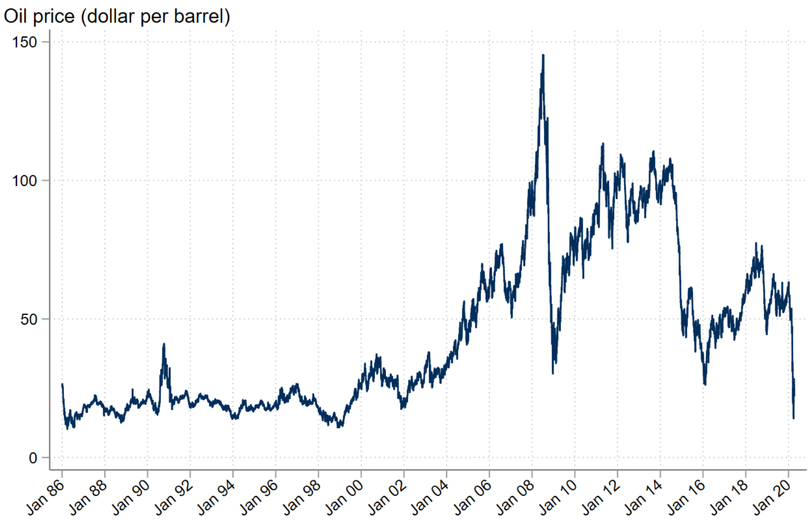
(a) Since 1990 (b) Since 2018



Notes: weekly oil consumption in the US (in thousand of barrels per day) and 5-week moving average. Left-hand side figure presents the series since 1990 and right-hand side figure restricts to the period 2018-2020. Source: EIA

companies, will have to confront the constraints and the risks of climate change mitigation commitments.[4]

Figure 2: WTI crude oil price (in dollar per barrel)



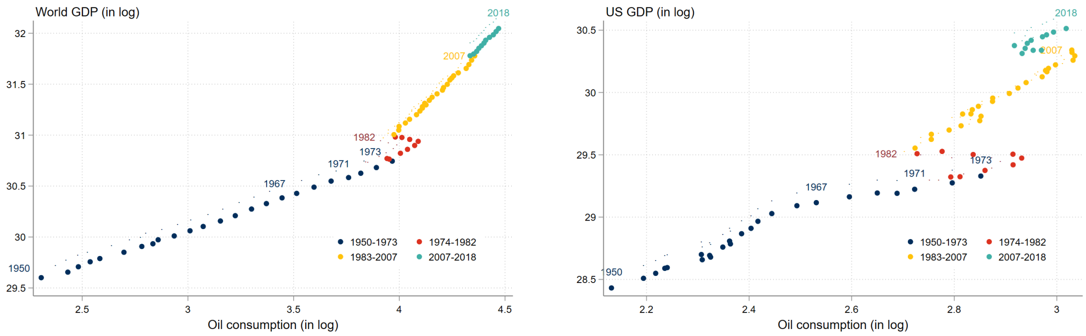
Taking a more macroeconomic view, the fact that petroleum, as a source of energy is strongly connected to GDP is almost tautological. As the economic grows, the demand for energy increases and if there is a shortage in the source of energy, then growth is more constrained. This is strongly corroborated by the data: since World War Two and with the exception of crisis periods, the correlation between the evolution of GDP and oil consumption is extremely strong, whether we consider the world as an aggregate (see

[4]See e.g. the UNEP emission gas report of November 2019.

Figure 3(a) and Lepetit, 2017) or individual developed countries (see Figure 3(b) for the US as well as Hamilton, 2009 and results hereafter).[5]

Figure 3: GDP and oil coupling

(a) World (b) USA



Notes: world GDP in million of 2010 dollars (in log) against oil consumption in million of barrels per day (in log). Source: World Bank (GDP) and BP and EIA (oil). Left-hand side panel is for the world, right-hand side panel for the US.

Analysing the sense of the causality (from GDP to oil or from oil to GDP) has been the focus of a very large literature that started as early as the 1970s (Kraft and Kraft, 1978, Stern, 2000). Results are nicely surveyed in Stern (2010) and have been subject to various methodological controversy. Stern (2000) shows that energy use causes GDP growth in applying vector auto-regression model in energy and economic time series.

Surprisingly, the economic analysis devoted to development accounting usually underrates the direct role of oil as a driver of long-term growth. The standard neo-classical approach in economic growth considers that production results from the combination of production factors, with an elasticity that is equal to their cost-share.[6] In the neoclassical model, the two factors of production are labour and capital, with relative factor share usually taken respectively around 70% and 30%. Energy and other raw materials are often absent from the list of production factors and are often considered as intermediate inputs, which do not directly concern the production function. Even if energy were added in the list of production function, the cost-share theorem suggests that its elasticity should be rather low. Ayres (2001) disputes this view and highlights the apparent contradiction between this low expenditure share of energy (and oil in particular) and its empirical relevance in explaining GDP.

[5]Interestingly, there is an important break for the US in 1966-1967. While this break has been identified for GDP by e.g. Bergeaud et al. (2016) and Maury et al. (2004) and its reason is still unclear. It could be the result of the rising engagement in the Vietnam War which significantly increased the demand for oil (see e.g. Holly, 1999).

[6]This result known as the cost-share theorem is true under a number of standard assumptions: e.g. constant return to scale of the production function and perfect competition.

For this reason, the role of oil in explaining long-run growth has been usually overlooked,[7] with two notable exceptions. First historians have long emphasised the fundamental role of energy and energy transition in shaping notable historic events (see e.g. Philippe, 1980, Arnoux, 2015, Wrigley, 2016 and Smil, 2010, 2017). Second, ecological economists have developed model of growth from the biophysical foundations of economy in which energy takes a central place as the necessary input in any economic transaction and production process (see Ayres and Warr, 2010).[8]

Some historians like Allen (2009) defend the view that energy are at the source of industrial revolution. Looking at the technologies that fuelled the "one-big-wave" of productivity (Gordon, 2012) of the US economic growth in the mid-20th century, it is clear that oil is ubiquitous. The large diffusion of innovations that framed the second industrial revolutions: ground transportation, electrification, heavy-industry, chemistry... was made possible thanks to the availability of a relatively cheap and efficient source of energy: oil.[9] These technologies did impact the efficiency of production, or total factor productivity (TFP). This has been shown empirically by Bergeaud et al. (2018) who showed how variation in electricity consumption explain variation in TFP since the 1930s, with a large contribution during the after WW2 period, but also during the IT wave in the US during the 1990s.

In spite of these evidence, most of the economic interest has been devoted in looking at the relevance of price as opposed to quantities of oil (see e.g. Kilian, 2009). Giraud and Kahraman (2014) argue that this focus has been misleading because the price of oil is a very complex object that is driven by economic and non-economic parameters (see Bergeaud and Raimbault, 2020 for a discussion in the case of gasoline). Looking at the historical variations of oil price, it is clear that the correlation with consumption is not straightforward. Hamilton (2009, 2013) explains that income rather than price is the key driver of quantity demanded.

Such highlight is important in feeding the debate about economic decoupling, that is, about analysing the long-run dependency of GDP to energy, and in this context, to oil and greenhouse gas emission. This very active literature is reviewed in Haberl et al. (2020) and Ahmad et al. (2020).

[7] In endogenous growth model (e.g. Aghion and Howitt, 1998), energy is absent as a direct driver of growth. However, these models have explore the possibility of long-term growth in a context of non-renewable resource.

[8] Although some early attempts have been made by economists to include energy as a production factor, see Missemer and Nadaud, 2020 for a review.

[9] Most economists acknowledge the role of electricity, as a general purpose technology (see Lipsey et al., 2005), to explain the take-off of US productivity growth during the 1920s (see Bakker et al. (2019) and Bergeaud et al., 2018) which was made possible by the availability of oil.

In a context in which economic uncertainty is at its highest and when climate change mitigation policies put unprecedented pressure on oil, it is essential to be able to put the current evolution into a historical perspective (Massard-Guilbaud, 2018).

2 A new dataset

There are many databases on the price of oil over a relatively long time period.[10] Data are also available on the production of oil by country. Much less information is available on the use of oil. This is what the present project and database is after. We expect these data to help researcher to work on the essential link between material energy and economic growth or other characteristics of the real economy, on a very long term perspective. Looking far back in time allows to compare the current situation with other periods of importance stress for both oil and the economy. For most countries such periods include the two world wars which were tremendous energy and economic shocks, as well as the Great depression of the 1930s.

Such database also allows to look at important changes in the use of oil over time. This usage has changed somehow following the energy crises of the 1970s (see Dargay and Gately, 2010), and for the past decades, 60% of oil was transportation, and 95% of transportation has been oil.

Besides the COVID-19 pandemic and its temporary lock-down, the shift from oil toward a low carbon civilisation is the greatest challenge of our century.[11] Thanks to economic history and to the collected data, the *CH.DUPIN* program aims at shedding light on the decoupling of crude oil consumption and economic activity, a question that was at the heart of the actual unfolding of prospective scenarios (see Lepetit, 2017).

History will tell, but it is highly possible that in 2018 Human kind has seen peak oil production.

2.1 Construction of the data

From different sources, we construct an annual estimate of oil consumption in 16 countries since 1890. These are 12 European countries: Germany, France, the United Kingdom, Italy, Spain, the Netherlands, Switzerland, Sweden, Norway, Denmark, Finland and Portugal, the United States and Canada, Japan and Australia. As is often the case when compiling historical data that are consistent over time, we reason on a constant border,

[10] BPSTAT provides excellent price series. WTI, Middle East and Brent daily prices on a very long horizon are also available.

[11] For the role of energy and oil see Smil (2017). For a history of oil see Auzanneau (2018)

i.e. in the case of countries that underwent major territorial changes during the 20^{th} century (in particular Germany), we reconstruct a fictitious country corresponding to the current borders in the past.

We start from the EIA (Energy Information Administration) "Petroleum and other liquids" series covering the period 1972-2017. These data are then supplemented in the past by the British Petroleum Review of World Energy data, which allow us to go back to 1965 for all countries. There is no systematic source for going back to the past before 1965. Different studies have proposed estimates for some countries, for example Kander (2002) for Sweden, Malanima (2006) for Italy or Steward (1978) for Canada. We will consider this type of source on a case-by-case basis, but in particular we will use a new data source developed over the years by Jean-Marie Martin-Amouroux[12] and never published. A country-by-country breakdown of the sources used are available in the Appendix.

Our work is closely related to the Power to the people project (Kander et al., 2015). We build on their work by extending the set of countries (and planning to extend further our geographical coverage), by using new data sources and by completing our data with information on economic outcomes.

These data are further supplemented by annual estimates of GDP, population and productivity obtained via Bergeaud et al. (2016).

2.2 A brief presentation of the data

In 2017, the last point at our disposal, per capita consumption shows a large divergence between most European countries and the United States, Australia and Canada (see Figure 4). The situation was different before the oil shock in 1970, with higher levels and less divergence between Europe and the rest of the world (Figure 5). In fact, the dispersion of consumption as measured by the coefficient of variation has been decreasing since the end of the Second World War, reaching its minimum in the 1990s and increasing again slightly since then. This significant decrease since the end of the 1940s is consistent with the economic "Great Convergence" which sees GDP per capita levels between developed countries moving closer together (Bergeaud et al., 2019). More details are given in Table 1 where we present average growth of oil consumption for each countries and for different subperiods.

Over the whole period, we do see a strong correlation between economic activity (as measured by GDP) and oil consumption. This can be shown in Figure 6 where we have reported the logarithm of GDP per capita against the logarithm of total oil consumption, controlling for invariant country specific characteristics. This rather strong correlation

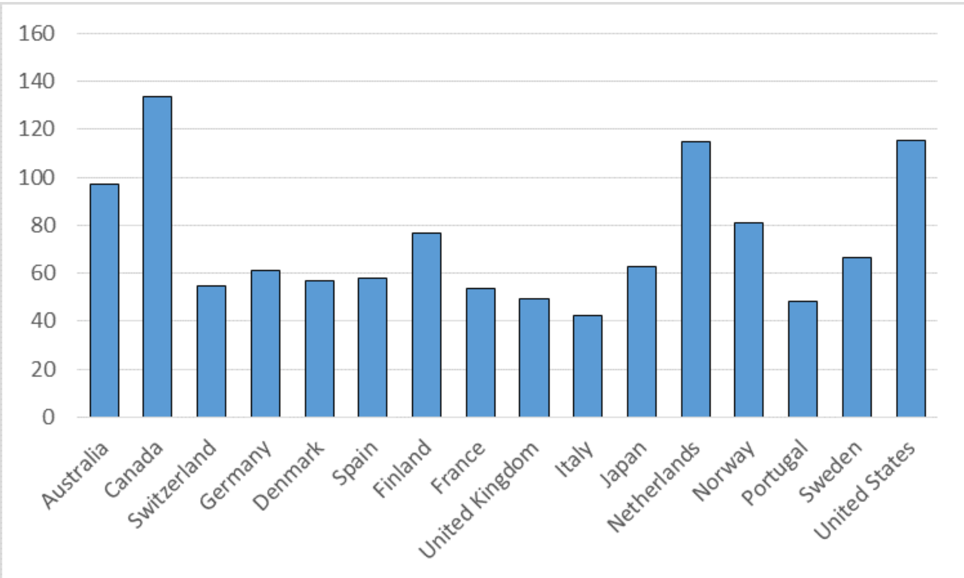
[12] See the dedicated webpage: l'encyclopédie de l'énergie - Consommation mondiale d'énergie 1800-2000.

Table 1: Average growth rate of oil consumption for different subperiods

	AUS	CAN	CHE	DEU	DNK	ESP	FIN	FRA	GBR	ITA	JPN	NLD	NOR	PRT	SWE	USA
1913-1950	28.7%	8.9%	42.6%	11.9%	31.2%	29.6%	23.0%	36.2%	8.3%	151%	9.2%	340%	14.8%	11.8%	33.4%	5.7%
1950-1972	16.2%	5.8%	11.4%	20.1%	11.8%	12.1%	15.3%	10%	7.8%	15.3%	23.5%	10.5%	6.9%	9.6%	9.4%	3.0%
1973-1983	0.3%	-1.9%	-1.8%	-1.2%	-5.3%	4.2%	-1.7%	-2.4%	-3.4%	-1.0%	-1.4%	-2.8%	-0.5%	4.9%	-4.3%	-1.7%
1984-2007	0.8%	1.0%	-0.8%	-0.6%	-0.9%	1.3%	0.0%	-0.3%	0.2%	-0.3%	0.0 %	1.9%	0.9%	1.9%	-0.7%	0.2%
2008-2017[2]	0.2%	-1.1%	-2.2%	0.0%	-2.4%	-2.4%	-1.5%	-1.7%	-1.6%	-3.6%	-2.1%	-1.9%	-2.3%	-2.1%	-1.5%	-1.4%

hide different realities at different subperiods as was already shown by Lepetit (2017). To show this, we replicate Figure 3(a) for France and Great-Britain (see Figure 7). We do see that the period following WW2 and preceding the oil crisis of the 1970s is characterised by a dramatically strong correlation between the two quantities, especially in the case of France. This is important, as this period corresponds to the big wave of productivity experienced by most European countries. This strong correlation suggests that most of the productivity gains of these decades correspond to the diffusion and adoption of technologies that are actually fuelled by oil (see Bergeaud et al., 2018 for a discussion on the role of electrification in explaining the evolution of long-run productivity).

Figure 4: Oil consumption per capita (in millions of Btu per inhabitants) in 2017



2.3 Country by country results

In this section, we show the time series for each of our 16 countries in which we plot the evolution of the logarithm of oil consumption over time. All the data and more can be downloaded in the dedicated website.

Figure 5: Oil consumption per capita (in millions of Btu per inhabitants) in 1970

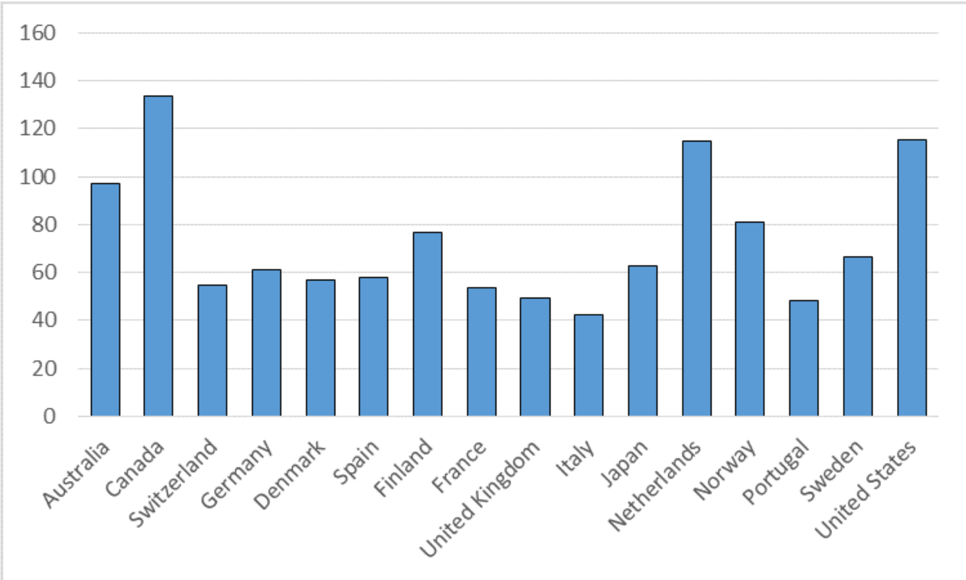


Figure 6: oil consumption (in log) against GDP per capita also in log. Absorbing country fixed effects

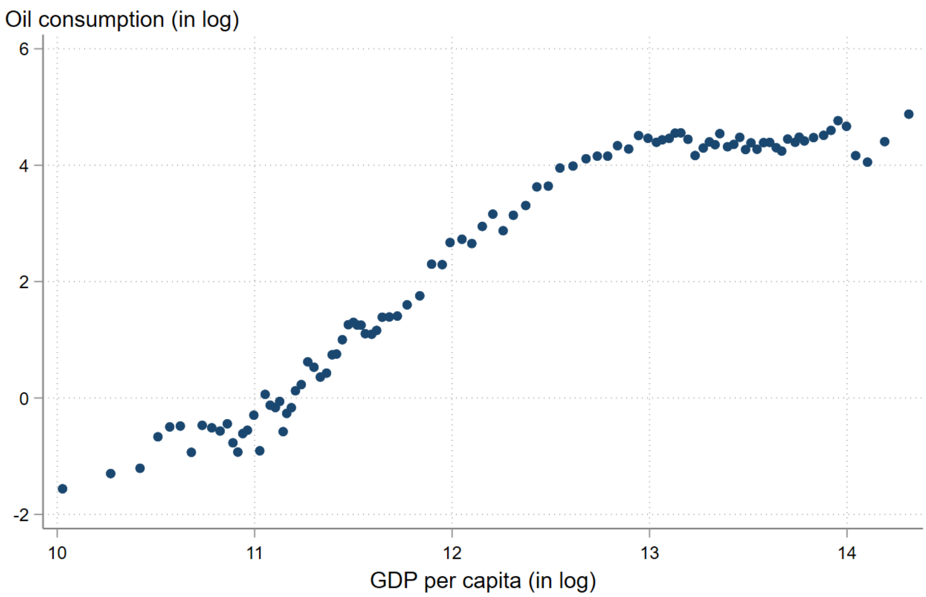
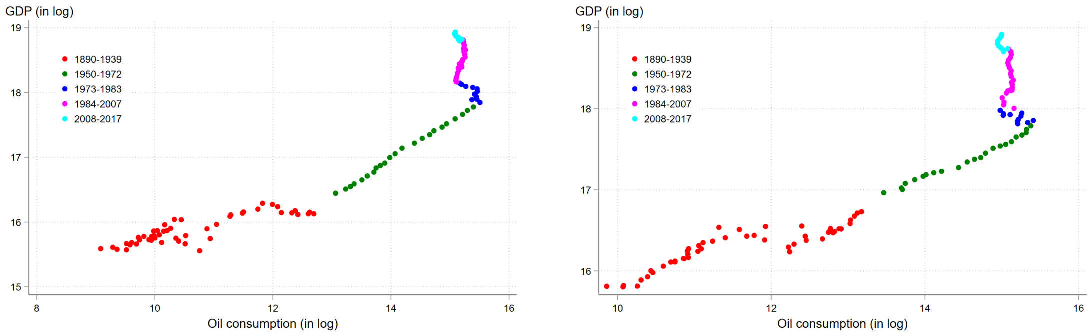


Figure 7: Oil consumption and GDP

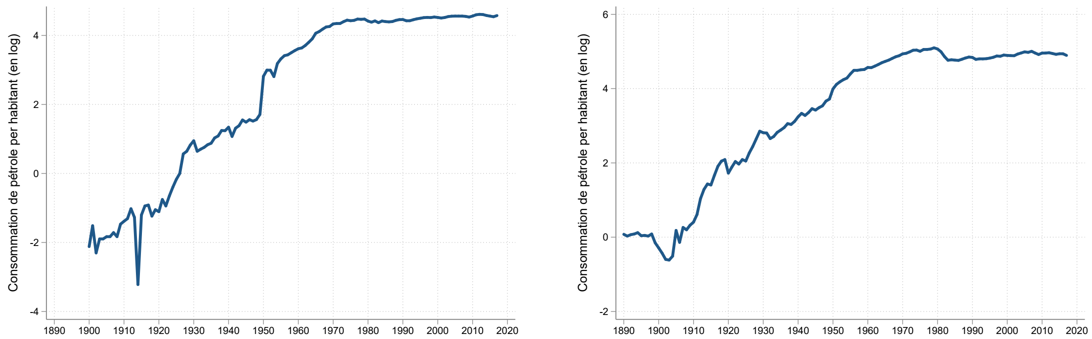
(a) France (b) United Kingdom



Notes: oil consumption (in log) against GDP also in log for France (left hand side) and the United Kingdom (right hand side).

Figure 8: Time series

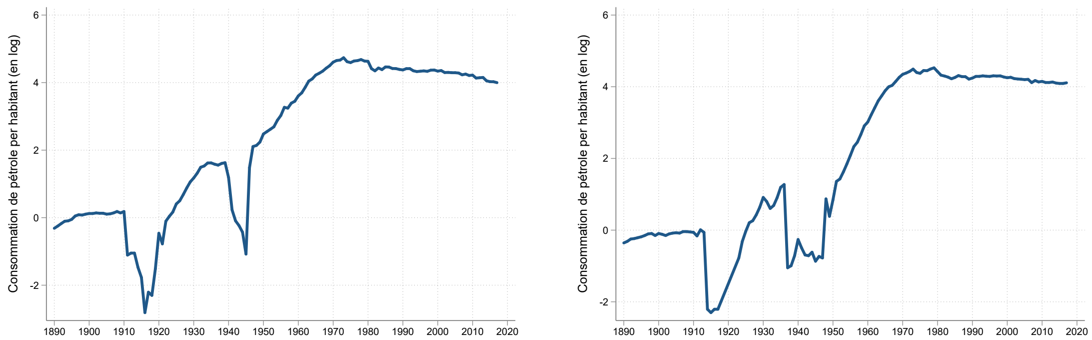
(a) Australia (b) Canada



Notes: oil consumption (in log) for Australia and Canada.

Figure 9: Time series

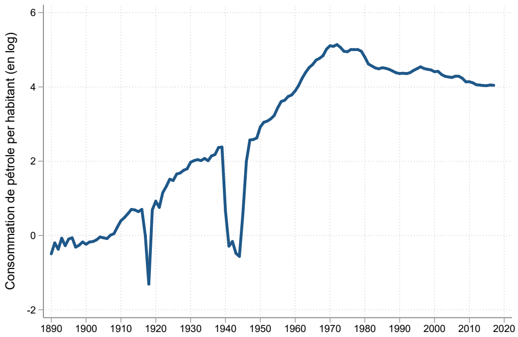
(a) Switzerland (b) Germany



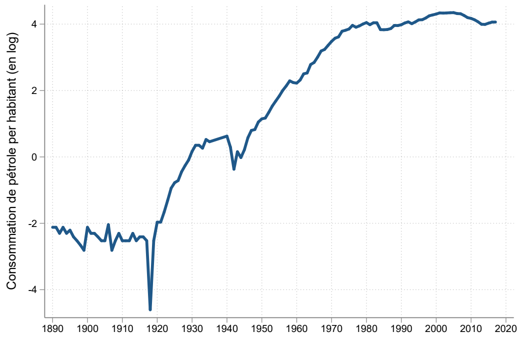
Notes: oil consumption (in log) for Switzerland and Germany.

Figure 10: Time series

(a) Denmark



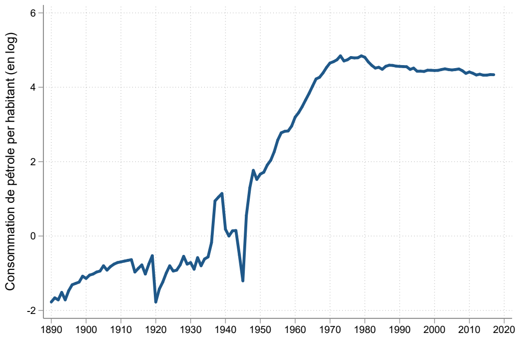
(b) Spain



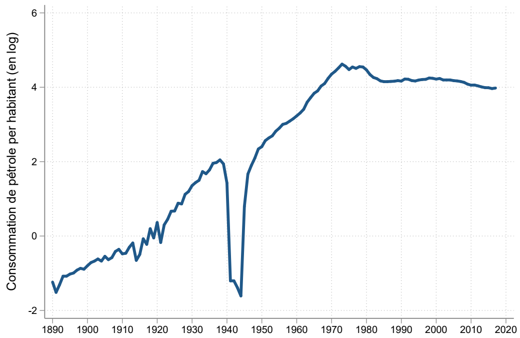
Notes: oil consumption (in log) for Denmark and Spain.

Figure 11: Time series

(a) Finland



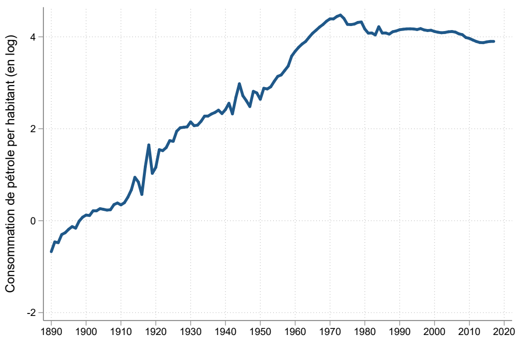
(b) France



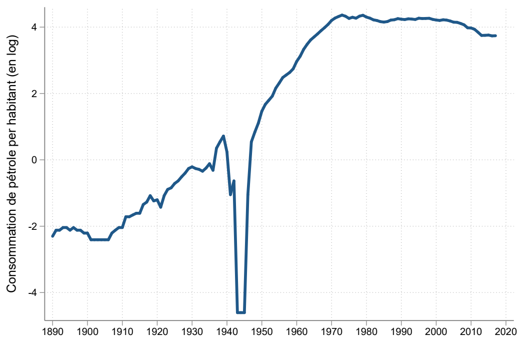
Notes: oil consumption (in log) for Finland and France.

Figure 12: Time series

(a) United Kingdom



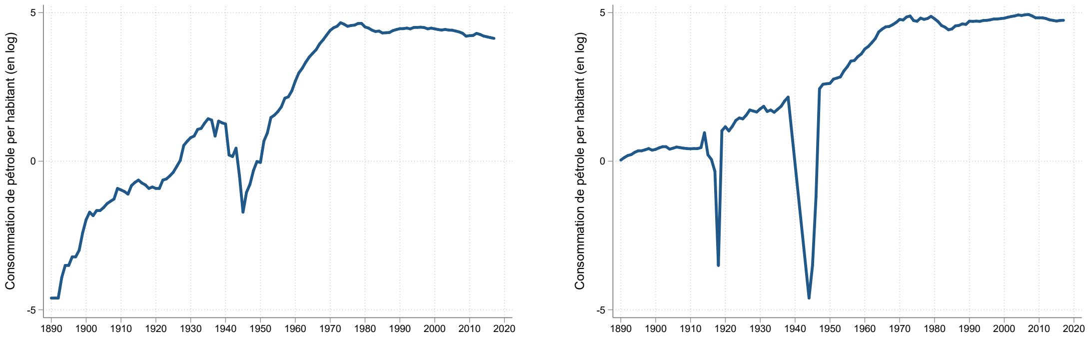
(b) Italy



Notes: oil consumption (in log) for United-Kingdom and Italy.

Figure 13: Time series

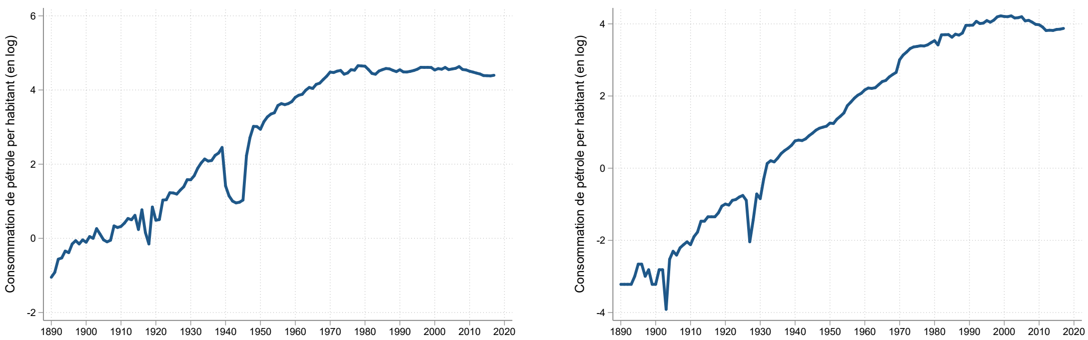
(a) Japan (b) Netherlands



Notes: oil consumption (in log) for Japan and Netherlands.

Figure 14: Time series

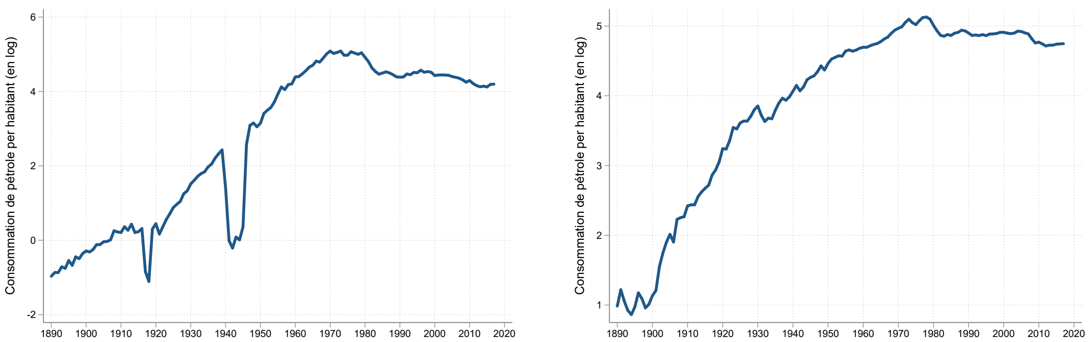
(a) Norway (b) Portugal



Notes: oil consumption (in log) for Norway and Portugal.

Figure 15: Time series

(a) Sweden (b) United-States



Notes: oil consumption (in log) for Sweden and the US.

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Appendix

A Source

We present the various sources that we compiled, compared and combined to create our dataset. Our starting point for every country are the EIA "Petroleum and other liquids" series covering the period 1972-2017. These data are then supplemented in the past by the British Petroleum Review of World Energy data, which allow us to go back to 1965 for all countries.

To go further back in time, our preferred source comes from the work of Jean-Marie Martin-Amouroux (JMMA hereafter) (see the "Encyclopedie de l'Energie") who carefully built estimates of the yearly consumption of oil based on data on production, import, export and stock. Alternative sources have also been used and consider to complete these series.

Australia (AUS)

For Australia, we only considered the data from JMMA without any alternative sources. We consider the data before 1900 to be less reliable and do not include them, although we conjecture that oil consumption between 1890 and 1900 is very close to 0.

Canada (CAN)

STATCAN (1983), the national statistical office of Canada provides estimates of oil consumption in their publication "Historical Statistics of Canada, Section Q". Alternatively, Steward (1978) offer historical data on oil consumption in Canada, from 1900 until the 1970s. For earlier estimates, we rely on information provided by JMMA.

Switzerland (CHE)

Bundesamt fur Energie (2015) provides historical series from 1910 which we backdate using data from JMMA.

Germany (DEU)

Kander et al. (2015) provides data from Germany from 1870 taken from Ben Gales and Paul Warde's original series. The case of Germany is particularly difficult given the various territorial changes and both Kander et al. (2015) and JMMA considered constant border.

Important adjustment have been made during World War two, although we believe the subject of German oil consumption during the war deserves much more attention that awaits further research. In the meantime, we used data from JMMA.

Denmark (DNK)

Henriques and Borowiecki (2017) provide estimate for Denmark since 1874 that are very similar to those of JMMA.

Spain (ESP)

Historical series are provided by Carreras and Tafunell (2005) since 1870 that are highly correlated with JMMA. The oil consumption series is discontinued during the Spanish civil war during which Kander et al. (2015) assume a consumption of 0. We follow this assumption but as in the case of Germany, we stress the need for further research.

Finland (FIN)

For Finland, we only considered information from JMMA.

France (FRA)

For France we use Villa et al. (1998) who provided historical data taken from Rouchet (1997) and made available from the CEPII. During the period 1926-1947, we rely on the work of Putnam (1953) that provides very detailed information for a small number of country.

United Kingdom (GBR)

Warde (2007) provides estimates from 1857 that are very similar to these of JMMA.

Italy (ITA)

Malanima (2006) and Kander et al. (2015) estimate Italian oil consumption from 1870. These data are close to these of JMMA with some small differences before WW2. We consider JMMA data.

Japan (JPN)

For Japan, we use JMMA except during the years 1926-1947 where we rely on Putnam (1953)'s estimates.

Netherlands (NLD)

For Netherlands we only considered the data from JMMA.

Norway (NOR)

For Norway, we used JMMA as our only source

Portugal (PRT)

Henriques (2009) provides information on oil consumption in Portugal. Unfortunately, JMMA does not provide any estimate for Portugal so we only considered data from Henriques (2009).

Sweden (SWE)

For Sweden, we rely on the work of Kander (2002) whose estimates are very detailed and in line with these of JMMA.

United States (USA)

For the US, we combined information taken from Shurr and Netschert (1960) and from Putnam (1953).