Oil and the economy

A systematic review of the literature for ecological economists

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This article offers a systematic review of the literature in oil economics, macroeconomics (international and financial economics) and political economy, complementing and complicating the way ecological economics understands the links between oil and the economy. We look at the supply and demand factors that affect oil prices; the ways oil prices affect the economy; the effect of interest rates, capital flows and exchange rates on oil prices and extraction; and the role of (geo) politics in governing oil and money flows. We develop an illustrative system model of the causal pathways that link oil and the economy and compare alternative explanations of the oil price shocks of the 1970s and 2000s. The emphasis of ecological economics on peak oil and resource limits to growth may be relevant over the long run, but is less capable of explaining precisely how oil contributes to concrete economic short-run crises now.

Energy; peak oil; macro-economics; political economy; capital flows; monetary policy

The current (2008) financial debacle is not a 'liquidity' crisis as it is often euphemistically called. It is a crisis of overgrowth of financial assets relative to growth of real wealth ...Can the economy grow fast enough in real terms to redeem the massive increase in debt? In a word no .. Growth in US real wealth is restrained by increasing scarcity of natural resources, both at the source end (oil depletion), and the sink end (absorptive capacity of the atmosphere for CO2)

Herman Daly (2014, p. 211)

Peak oil also contributed to the current crisis. The spike in oil prices to greater than \$140 per barrel and the spike in gasoline prices it caused was a trigger to expose the house of cards that the housing market had become. The recession eased demand and brought oil prices down, but if the stimulus packaged work, then demand will outstrip supply again, another oil price spike, and another recession.

Robert Goodland (2016, p. 42)

The present economic crisis is not only a financial crisis, and it was not caused only by a supply of new houses in the United States that exceeded the demand that could be financed sustainably. It was also caused by high oil prices. The stock exchange started to drop in January 2008 but until July 2008 the price of oil kept increasing. As the crisis deepened, the price of oil went down but it recovered in real terms. There is here an automatic de-stabiliser for the economy. It is difficult to find new oil as we go down the Hubbert curve.

Joan Martinez-Alier (2016, p.287)

1. Introduction

In July 2008 the nominal price of oil reached USD 133.40 a barrel, a five-fold (500%) increase from 2002. In September 2008 Lehman Brothers declared bankruptcy, marking the abrupt beginning of a global economic crisis from which advanced economies have not fully recovered. Prominent ecological economists such as Herman Daly, Robert Goodland and Joan Martinez-Alier suggest a direct causal link from peak oil to high oil prices to low growth and economic crisis. In contradistinction to neoclassical resource or environmental economics, a core thesis of ecological economics is that "increased energy use is the main or only cause of economic growth" (Stern, 2011, 30) and that abundant and cheap energy has been historically a major driver of economic growth (Ayres and Warr, 2009, Cleveland et al, 1984). Peak oil and declining energy returns on energy investment for oil and other primary energy resources (Murphy and Hall, 2010) are then likely to limit economic growth and cause recession (Martinez-Alier, 2016, Tverberg, 2012). Mainstream economics is more optimistic about the capacity of advanced economies to overcome resource limits given technological change and the possibilities of substitution. Ecological economists instead argue that fossil fuels had remarkably high EROIs and substitute energy sources will not be able to sustain contemporary levels of economic output. There are limits also to the substitution of energy by other factors of production (e.g. capital or knowledge); such substitutes require substantial amounts of energy too. Technological change does not alter these limits, since it is just another name for substitution (see review in Stern, 2011). The

end of cheap oil, ecological economists argue, therefore will bring the end of the era of dramatic, continuous economic growth.

Ecological economists may be right that limits in oil supply will limit economic growth in the future, but is this sufficient proof that the 2008 crisis resulted from increasing oil scarcity, as Daly, Goodland and Martinez-Alier suggest? The 1970s oil crisis gave birth to the “limits to growth” movement, and to the community of ecological economics. By now we know that that crisis had less to do with depletion or ‘running out of oil’ (though domestic peak oil in the US may have arguably contributed to a massive global economic change); the primary causes of the economic dislocation of the 70s were geopolitical and economic (Mitchell, 2011). Today oil prices remain low while the global economy grows: is this proof that ecological economists were again too quick to presume that physical oil scarcity was an enduring reality, producing perpetually high oil prices, which in turn caused financial and economic crisis?

Beyond predicting ultimate limits to growth, ecological economics has less to say about the interdependent factors that connect oil and the economy in the short-term, and the role of political and monetary forces. Ecological economics for example is mute on how monetary policy, interest rates, or capital flows affect resource markets and resource use, treating them as epiphenomena, a “virtual economy” top resting upon the base of the “real-real” economy of biophysical stocks and flows (Daly, 2014, Martinez-Alier, 2016). We believe, however, in the spirit of Keynes, that the financial economy is integral to the understanding of the physical economy; we find it useful, however difficult, to try to understand and explain the complex interrelationships between resource and money flows, and the role of (geo)politics and power in governing them. Toward this end, this article offers a systematic review of the literature in oil economics, macroeconomics (international and financial economics) and political economy, complementing and complicating the way ecological economics understands the links between oil and the economy.

An oil price shock preceded all but one of the eleven U.S. recessions since World War II (Hamilton, 2012). Figure 1 illustrates the direct correspondence between high oil prices (indicated here relative to gold prices to distinguish between oil and general price increases) and US recessions. One might deduce from this that a rise in the price of oil *causes* an economic downturn. Yet oil prices are endogenous to macro-economic conditions (Kilian, 2008), making it hard to infer directionality. In other words, the causation may be inverse: it could be that an economic expansion increases the demand for oil and its price and an economic downturn reduces it. Or it might be the case that both oil prices and economic output respond to some third variable, such as interest rates, capital flows or a structural or policy change. Interest rates and capital flows—or oil investment, extraction and trade—are not pure market outcomes; they are influenced, if not determined, by politics and geopolitical relations.

Figure 1. Oil/Gold Price Ratio, 1967-2015 (Normalized), With US Recession Bars (source: Sager, 2015 from IMF data)

This paper sets out to enrich the standard causal model implied by ecological economists, according to which the depletion of oil resources increases their prices and acts as a brake to the economy (figure 2). We engage first with the complex mechanisms through which oil prices affect the economy and the evidence that there is in their support (section 2). Next, we review evidence about the demand and supply factors that influence oil prices (section 3), before turning to the ways in which capital flows and monetary policies influence prices and extraction (section 4). Sections 2 and 3 comprise in essence a review of the literature of oil economics, with some focus on Lutz Killian and James Hamilton, two key researchers with some differences of view in certain aspects. Section 4 is a review of the literature in international and financial economics, where the contributions of economists such as Jeffrey Frankel or Ricardo Caballero stand out. Section 5 provides a briefer and more selective review of the complex geopolitics of oil and money flows. Section 6 compares the insights from these different scholar communities and from ecological economics, concluding with key lessons for the latter. We focus not only on the 2008 and 1970s crises, but also on the periods of low oil prices that dominated in the later 1980s and from mid-2014, as well as the early 2000s when prices reached record highs without noticeable effects on the economy.

Figure 2. A simple causal model linking oil and the economy¹

¹ We will use causal loop terminology and illustrations to build a more integrated mental model of oil and the economy (see figures 2-5). A “+” sign means that an increase (decrease) in the variable from where the arrow leaves causes an increase (decrease) in the variable where it arrives—a positive

Three disclaimers: first, this literature review addresses ecological economists with some degree of affinity for the opening statements by Daly, Goodland and Martinez-Alier; our purposes and line of arguing will make less sense to those who take it for granted that there is definitely no peak oil and that an economic crisis has nothing to do with resource limits. Second, this is a selective review: the intention is to enrich the ecological economic model, rather than exhaustively cover all literature on oil. The reader interested in more technical reviews may consult Kilian (2014, 2008) or Hamilton (2012, 2008); for an interdisciplinary review of the political economy literature, Bridge and Le Billon (2013) are an excellent starting point. Third, we do not aim here to contribute to the oil economics literature, which is covered exhaustively by Kilian or Hamilton. Like all others, this literature has a limited domain, often abstracting, for example, away from monetary, political and ecological factors. The spirit of our review is interdisciplinary, the premise being that no single community has all the answers to such a complex set of questions.

We use system model terminology to represent visually and more systematically the causal relationships identified verbally in the review. Following the early 1970s *Limits to Growth* report of the Club of Rome, system models became a popular method among ecological economists. Our intention here is not to build a formal mega-model of oil and the economy, but rather to force some discipline and transparency on our propositions. We believe that more formal models may be built by other ecological economists, however, who are welcome to use (parts of) our models for simulations and scenarios as they wish.

In general we follow the U.S.-centered outlook of the literature, and by ‘economy’ (or GDP or interest rates in our diagrams) we refer to the U.S. economy. This makes sense in so far as the US is the largest consumer of oil, and the economy in which the global financial crisis started. In some instances, however, we raise the limitations of this approach and note differences with other parts of the world.

2. The effects of oil prices on the economy

Oil prices may affect economic activity both through the supply side and the demand side: that is via production or consumption. Rising oil prices can increase the cost of production of firms, especially of energy-intensive ones (R1, Figure 3), and/or reduce labor productivity (R2, Fig.3), also raising the costs of production. The production channel is the one that implicitly concerns ecological economists. Ecological economists have theorized and documented empirically that low energy prices are related to increases in labour productivity (Cleveland et al, 1984) and economic growth (Ayres and Warr, 2009). Periods of high economic growth of the US economy are associated with low expenditures on energy: positive growth requires expenditures less than 11% of GDP, which translate into a minimum EROI (energy return on energy investment) of 11:1 (Fizaine and Court, 2016). Garcia-Olivares and Ballabrera-Poy (2014), using an Ayres production function where energy

relationship. A “–” means that an increase (decrease) causes a decrease (increase)—a negative relationship. Figure 2 thus shows that an increase in oil prices, other factors equal, will increase the costs of production, causing a decrease of output/GDP. Equivalently, a decrease in the oil price should reduce costs and in turn increase GDP. This basic mental model of oil and the economy, however, requires revision and elaboration.

intensity (exergy) matters, and assuming a peak of fossil fuels by 2038, show that growth in the U.S. economy is likely to come to an end some time between 2050 and 2150, a quite wide prediction window.

Kilian (2008) identifies six complementary ways through which oil prices may affect expenditures: households reducing other operational expenditures to compensate for a higher share of energy in their budgets (“income effect”); consumers postponing irreversible purchases of durables until energy prices settle (“uncertainty effect”); households saving more out of fear for the difficult future signaled by high oil prices (“precautionary effect”); households reducing their acquisition of energy-intensive durables, most notably cars (“durables effect”); reductions in the expenditures of firms that are directly involved in energy or energy-intensive services; and “reallocation”, or second-order effects, where sectoral downturns due to high oil prices (eg., in the car industry) cause unemployment and a general reduction in consumption. Looking at the period 1970–2006, Edelstein and Kilian (2009) find that the effects of oil prices on expenditures were generally small, although much larger than what energy’s cost share alone would suggest. While energy price shocks

explained historical US consumption growth, they were by no means the dominant factor. According to their data, oil shocks make themselves felt “primarily through reduced demand for cars and new houses” (i.e. R4-5, Fig.3) (Kilian, 2008, 889). In a later study, however, that focuses on the period 2007-2008 and the economic crisis, Hamilton (2009) finds a much more significant effect: the rise in energy prices accounts, he argues, for about half of the gap between predicted and actual consumption spending. As Kilian and Edelstein predicted, the impact was felt primarily through reduced demand for cars. Had there been no decline in the output of the automobile sector, Hamilton finds, what turned out to be a recessionary (+0.75%) GDP growth between the fourth quarter (Q4) of 2007 and Q3 2008 would be a 1.2% growth at an annualized rate, which would not qualify the period as a recession. Oil prices, Hamilton argues, reduced demand for cars, causing a decline of the automobile sector, which in turn tilted the U.S. economy into a recession (R3-R4, Fig.3).

Yet how certain can we be that reduced demand for cars was the result of an increase in oil prices rather than, say, a decline in incomes? If the latter were the case, Hamilton argues, all car sales should have declined. What happened instead was a 25% reduction for gasoline-intensive SUVs, compared to only a 7% reduction for other domestic car sales, while the sales of imported cars increased by 10%. Hamilton (2009, 256) concludes therefore that “the oil shock indisputably contributed” to the collapse in domestic car purchases, which together with deteriorating consumer sentiment and a slowdown in overall consumption pushed the U.S. economy over the recessionary cliff.

Oil prices, however, had increased inexorably from 2002 to 2007 (figure 1). Why did they not impact consumer spending earlier? Indeed, up until 2008 it was this paradox—not the means by which high prices affect the economy—that concerned economists. Why did the sharp and durable rise in oil prices between 2002 and 2007 not have the dramatic effects of the 1970s shocks (Blinder and Rudd, 2008)? The general consensus was that the link between oil prices and the economy had been broken. Four propositions were put forward to explain this: first, that the increase in prices in the 2000s was gradual and not abrupt as in the 1970s. This was thought to have given the economy time to adjust and reallocate. Second, that the US economy was much less dependant on energy than before and hence a rise in energy costs had much less of an impact (Nordhaus, 2007). Third, that labor markets were now more flexible, and higher costs as a result of oil prices were absorbed by lower wages (Nordhaus, 2007). The fourth explanation was that the structure of the car industry had changed, American companies producing fuel-efficient domestic cars, the sales of which increased as oil prices went up (Kilian, 2008). (A fifth explanation that we will present below is that it was not oil prices per se that affected the economy in the 1970s, but bad macroeconomic policy responses, which by the 2000s had been corrected).

The apparent decline however in the dependence of the economy on energy, measured as it was by the share of energy in the GD was an artifact of low oil prices, and was gradually reversed with the increase in oil prices after 2002. As Hamilton (2009) argues, in the first years of rising oil prices Americans could well afford to ignore the increase. The change though was cumulative and at some point a threshold was reached, energy costs becoming a sufficiently large part of household budgets that they could no longer be ignored without serious reallocations and reductions in expenditures. Spencer et al (2012), using data from the Consumer Expenditures Survey of 2011, find that in 2008 the average US household spent \$2,715 for gasoline, 120% more than the \$1,235 it spent in 2002. *For poorer households the rise was even steeper, from \$1,422 in 2003 to \$3,196 in 2008.* The

'absorption' of rising energy costs by real wages (Nordhaus, 2007), likely became a liability: as wages stagnated or declined, so did aggregate demand (R6, Fig.3). Here one might speculate on a link between the oil and the private debt crisis, in so far as households may have coped with stagnating wages in the face of rising oil prices by borrowing.

If Kilian and Edelstein's analysis holds, then reduced expenditures must have affected not only car purchases but also house sales. Furthermore, Hamilton (2009), citing Cortright (2008), notes that home prices in 2007 rose slightly in zip codes closest to metropolitan centers but fell significantly in zip codes with longer average commuting distances. This was plausibly an effect of the rising price of gasoline (R7, Fig.3). Anecdotal evidence suggests that the majority of mortgage delinquencies after 2007 were by low-income households living in the periphery of metropolitan areas hit by increasing commuting costs. Kaufman et al (2010) confirm a statistically significant causal effect of household energy prices on mortgage delinquency rates.

A separate causal mechanism through which high oil prices might affect the economy is via inflation, i.e. by raising general prices. This played no role in the 2008 crisis, given strong anti-inflation monetary policies and very low inflation. Kilian and Lewis (2011) had in any case rejected with empirical research the common wisdom, prevalent among economists as well, that high oil prices are inflationary. In some cases oil price shocks may even be deflationary due to their negative effects on consumer demand (Kilian, 2014). This does not mean, however, that macroeconomic policies based on policymakers' beliefs that oil prices are inflationary cannot have a negative effect.

Indeed, unlike oil economists, macro-economists tended in the past to attribute the negative economic effects of high oil prices to bad policy responses—not to their effects upon production or consumption. A popular argument among macro-economists was that the U.S. recessions that followed the big oil shocks in the 1970s were not caused by the increase in oil prices per se, but by the Federal Reserve's contractionary response to them. In this view what pushed the economy into recession was the ill-founded decision to raise interest rates in order to control the supposed oil-induced inflation (R8, Fig. 3) (Bernanke et al, 1997). This argument was mobilized in the early 2000s to explain why high oil prices had no negative effect in the economy. The reason supposedly was that inflation policy had changed and the mistakes of the past were no longer repeated, defusing the main pathway through which oil prices affected the economy. After the 1980s Federal Reserve policy responded to core rather than headline inflation (Nordhaus, 2007). Monetary authorities were also more independent, increasing the credibility of anti-inflation policy (Blanchard and Gali, 2007).

Of course the subsequent 2008 oil price shock and recession undermined the assertions of these macroeconomists that oil prices no longer affected the economy because monetary authorities had improved their policies. Even before the crisis Hamilton had contested the evidence that attributed the 1970s crises to an ill-considered macroeconomic policy response. He showed that even with the model and data that Blanchard and Gali used, had there been no oil shock, the severe downturn of 1974-75 would have been only a mild recession (Hamilton, 2009). Furthermore, he showed that the Bernanke et al. (1997) result was driven by a methodological choice (a shorter time lag) and calculated that if the Fed were to ease monetary policy to avoid recession, as Bernanke suggested it should have had, interest rates would have to be reduced to unrealistic levels given the historical experience at the time (Hamilton and Herrera, 2004). The oil price shock caused the crisis, Hamilton and Herrera insist, and macroeconomic policy could not have avoided this.

An interesting question is whether the causal relations suggested here (Figure 3) hold both ways. In other words whether, for example, declining oil prices reduce production costs or increase consumption, hence spurring economic activity. An ecological economist would respond that they certainly do, given that energy prices are linked to productivity and growth rates. But then again, unlike the contraction that followed the rise of oil prices in the 1970s, their steep fall in the second half of 1980s did not seem to be accompanied by a major economic expansion. As a result economists asked whether the response of the economy to oil prices is 'asymmetric': whether it differs between periods of rising and falling oil prices. This question is coming again to the forefront with the recent steep decline in oil prices. In their work, Edelstein and Kilian (2009) reject the hypothesis of asymmetry (or more precisely, find that the null hypothesis of symmetry cannot be statistically rejected). They attribute the relatively low U.S. GDP growth in the late 1980s to a 1986 tax reform that reduced firms' fixed investment expenditures and, interestingly, to the unprecedented fall in investment in the domestic oil and gas industry.

The latter was almost certainly linked to low oil prices. For countries that do not produce oil, low prices are good news (though this might be tempered if they earn a great deal of revenue exporting to oil-producing countries). Yet high prices are good news for oil producing countries while low prices, meanwhile, generally hurt the budgets of oil producers (R9, Fig. 3). U.S. domestic oil production grew more than 70% from 2007 to 2014 with the advent of shale oil but is now suffering from falling oil prices. As a result it is unclear whether the currently low oil prices will have an expansionary or recessionary effect in the U.S. economy (Krugman, 2014).

The story becomes more complicated if one considers imports and exports from and to oil producing countries. With rising oil prices, growth in oil producing countries may increase their demand for imports from the rest of the world, offsetting recessionary pressures in the latter (R10, Fig. 3). Indeed, with the notable exceptions of US and Japan, in 90% of the world's countries exports tend to move in the same direction as oil prices, rendering the adverse effects of high oil prices relatively mild and lagged (Rasmusen and Roitman, 2011). Likewise, the expansionary effect of low oil prices may also be tempered by declining exports to oil-producing countries. In conclusion, it is not easy to predict that high (low) prices will uniformly lead to a decrease (growth) of GDP in any given country, insofar as this depends on whether said country has a sizeable domestic oil industry, and whether it exports to oil producing countries.

3. The drivers of oil prices

Oil prices are determined, at least in part, by the supply or production of oil (S1, Figure 4) and the demand for it (S2, Fig.4). The supply of oil is affected by 1) acute events and disruptions in production, due, for example, to war (S3, Fig.4); 2) geological factors and constraints (S4, Fig.4); and 3) investments in new capacity or new technologies (S5, Fig.4).

Kilian (2009) distinguishes between increases in demand due to increasing industrial activity and growing global demand for all industrial commodities (S6, Fig.4) versus changes in demand due to changing expectations about future oil demand and supply (S7, Fig.4). Forecasts of global growth (S8, Fig.4), trends of rising demand for oil (S8b, Fig.4), or supply constraints (S9, Fig.4) give a precautionary incentive to buy and store oil in anticipation of

Kilian's distinction is important because empirical studies show that different supply or demand forces affect the economy in different ways (Kilian, 2008, 2014). A disruption of crude production due to a war in the Middle East is likely to cause a small and transitory increase in the price of oil and a decrease in economic activity within the first year. If the increase in oil price is instead due to growing industrial demand and global growth, rising exports offset the negative impacts of oil prices initially, as we mentioned above (\$10). In this case the negative effects of rising oil prices take time to appear. This offers an alternative explanation to the question of why the increase in oil prices in the 2000s did not have an economic impact before 2007: it was because rising prices were driven by global growth and industrial demand (mostly from Asia), Kilian argues. In comparison, an increase driven by shifting expectations causes an immediate, persistent and large change in the real price of oil that reaches its maximum after three years (Kilian, 2008).

The diagram illustrates the complex interactions within the oil market, showing how various factors influence each other through causal links. Key components include:

- Finite Oil reserves** and **Known Oil reserves**: Represented by a stock-and-flow diagram with **S4** (stock) and **S5** (flow).
- Oil Production**: Influenced by **Known Oil reserves** (S4), **Investment for new crude oil capacity** (S5), and **War & Disruptions** (S9).
- Oil Price**: A central node influenced by **Oil Production** (S11), **Investment in alternative energy sources** (S12), **Production from alternative energy sources** (S13), **Futures oil price** (S15), and **Speculation** (S14).
- Futures oil price**: Influenced by **Oil Price** (S15) and **Speculation** (S14).
- Speculation**: Influenced by **Futures oil price** (S14) and **Financialization** (S14).
- GDP** and **Global growth**: Influenced by **Speculation** (S14) and **Financialization** (S14).
- Industrial Demand** and **Actual demand for oil**: Influenced by **GDP** (S10) and **Global growth** (S10).
- Precautionary demand**: Influenced by **Oil Price** (S2) and **Actual demand for oil** (S8b).
- War & Disruptions**: Influenced by **Oil Price** (S3) and **Precautionary demand** (S9).
- Investment for new crude oil capacity**: Influenced by **Oil Price** (S11) and **Investment in alternative energy sources** (S12).
- Investment in alternative energy sources** and **Production from alternative energy sources**: Influenced by **Oil Price** (S12) and **Investment in alternative energy sources** (S13).

The diagram uses a color-coded system to represent different types of stocks and flows, with blue and green lines indicating specific causal links. The overall structure shows a complex web of feedback loops and delays, highlighting the dynamic nature of the oil market.

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Hamilton (2008) however insists that the 1970s oil price surge cannot be explained without the supply disruptions caused by war in the Middle East and OPEC's decisions to constrain supply. Kilian (2008) contends that his econometric studies find that events in Middle East have little predictive power and that decisions such as the Arab oil embargo of 1973-1974 were not exogenous, but endogenous responses to the state of the US and global economy, most notably inflation and the devaluation of the dollar (see section 4). Hamilton (2008) on the other hand notes that endogenous responses cannot account for abrupt shortfalls, such as the reduction in output by 5% within weeks of the Yom Kippur war.

Interestingly, both Hamilton (2009) and Kilian (2009b) agree that the price run-up of 2007-2008 was caused by strong demand in excess of a stagnating world production. As Hamilton (2009) puts it, the big news of the first half of 2008 was that \$100 oil was insufficient to reverse the growth of global demand or increase extraction rates. Experts spoke of limitations in Saudi production and signs of a near-term global oil peak. This stagnation of output between 2004 and 2009 may explain why the price of oil started rising faster than that of other commodities after 2005 (Kilian, 2008; see Figure 1) (for an alternative explanation based on capital flows, see Caballero et al, 2008 in the next section).

Ecological economists tend to attribute stagnating production to resource constraints or peak oil (S4, Fig.4). "Peak oil" refers to the maximum rate of production (extraction) of oil, after which it will start declining; the hypothesis is that oil discovery follows a normal curve, and that the rate of production sooner or later follows the same pattern (Kerschner and Capellán-Pérez, 2016). But stagnating production is not necessarily a sign of peak oil. It is difficult, for example, to determine from the outside whether the Saudis limited production because they could not pump more oil as key oilfields were depleted (S4, Fig.4), or because they strategically stored oil in the ground in order to benefit from high future prices. One of the key ways of reducing output is a long-term strategy of foregoing investment on developing new resources (S5 to S1, Fig.4), a strategy which can only be inferred, but never known with certainty to those not privy to these decisions (Smith, 2009). There are indications that OPEC countries did limit production in this way, as their production capacity has scarcely changed since 1973, leaving their exploitation intensity of proven reserves almost 4 times lower than that of non-OPEC countries (Smith, 2009).

With back of the envelope calculations, Smith (2009) finds that from OPEC's perspective, increased production would not be justified unless prices were expected to remain above \$50 per barrel (S11, Fig.4). These calculations are complicated by the fact that high oil prices favor the development of other energy sources (S12, Fig.4), most notably shale oil and gas in the U.S. or coal in China. The stagnation of global oil production between 2004 and 2009 was followed by a renewed growth between 2010 until recently, driven mostly by the growth of shale oil in the U.S., which in 2014 surpassed Saudi Arabia as the world's largest producer. Further, Saudi Arabia's production, which in 2010 was roughly the same as in 1991, increased 20% by 2015. According to some commentators, the recent spectacular decline in Brent crude oil prices (\$48 per barrel in June 2016, down from \$105 in June 2014) reflects a strategy by the main oil producers such as Saudi Arabia to reduce prices and make the new, tighter sources of shale oil in the U.S. uneconomical, throwing them out of the market (S1 and S12-S13, Fig.4). Baumeister and Kilian (2015) reject explanations that attribute the price decline to increasing production after 2014 in the U.S. or Libya, or to the news that OPEC would sustain production despite the increase of production in non-OPEC countries. They argue that pre-2014, about 1/3 of the price decrease was due to slower

global economic growth (S6, Fig.4) and the remaining 2/3 to unexpected increases in oil production and changed expectations about higher supplies (and lower prices) in the future (S7, Fig.4). After 2014, the main driver is expectations for a growth slowdown (S6 and S8, Fig.4), and possibly, but to a lesser extent, of higher global oil production (S1 and S9, Fig.4).

Where does this leave the “peak oil” argument? Conventional deposits did peak in the early 2000s and extraction from operating conventional oil wells is declining at a global average rate of around 4% to 7%. Production in 8 of the top 20 producing nations has already peaked. To offset this decline, production rate capacities similar to those of all current shale oil production in the USA would need to be added each year, or equal to the total crude oil capacity of Saudi Arabia every three years (Kerschner and Capellán-Pérez, 2016). Shale oil wells show exorbitantly high extraction decline rates; they reach their peak and are depleted much faster than conventional wells (Kerschner and Capellán-Pérez, 2016).

Apart from the ‘fundamental’ forces of supply and demand, another factor that has attracted attention, especially in relation to the surge in prices in the 2000s, is the financialization of oil markets (S14, Fig.4). There has been an undeniable increase in the proportion of investors who hold oil as a financial asset, without physical delivery, versus those who hold it as a commodity to use (Hamilton, 2009, Bridge and Le Billon, 2013). The crucial question, however, is whether and how an increase in the futures price of oil translates into an increase of its spot price today (S15, Fig.4). The link between speculative prices in the futures market and physical quantities today is not straightforward. Hamilton (2009) suggests that a link is possible if futures prices are used for price ‘information discovery’ today or if oil-producing countries are misled by the speculative purchases of oil futures contracts into reducing current production. Hu and Xiong (2013) do not find empirical support for these claims (also see Fattouh et al, 2012).

4. Interest rates, money flows and the oil market

There is a different body of theories, mostly in financial and international macroeconomics that traces changes in the price of oil to factors such as interest rates, currency exchange rates, current account balances and capital flows. Note that this literature is often not concerned with oil prices per se, but with financial development and capital flows, producing models that can then be used to explain changes in commodity prices. For example, according to what may be called the “easy money” theory, interest rates in the US and other developed economies caused the increase in oil and other commodity prices in the 2000s.

There are several different mechanisms through which this may have happened (Frankel, 2008). First, low interest rates encourage oil producers to store oil (T1, Fig.5), given that it will have a higher financial return in the future, relative to selling it now and getting (low) interest on the proceeds, a proposed mechanism that dates back to Hotelling (1931). The lack of increase in oil inventories in the 2000s (Smith, 2009), a period of historically low interest rates, appears to disprove this story, but the anecdotal evidence of Saudi Arabia holding back extraction and storing oil in the ground for the future can be taken as a tentative confirmation (Frankel, 2008). Similarly, if one follows this line of thinking, the more recent decline of oil prices may not be due primarily to reduced expectations of growth, as Kilian argues, but due to the declaration by the U.S. Federal Reserve of its intentions for monetary tightening in the near future (Frankel, 2014). Given that tightening monetary

policy can have contractive effects on the economy, these two potential causes may very well be related.

Monetary policy and inflation affect exchange rates (T2, Fig.5). A country that eases its monetary policy or a country that experiences inflation will face depreciation and hence an increase of the cost of oil in its own currency (T2b, Fig.5). Frankel (2008) finds empirical evidence of a correlation between interest rates and commodity prices for a range of commodities (though it is not statistically significant for oil). Inflation and depreciation of the dollar vis-à-vis Arab currencies after the collapse of the Bretton Woods system in the 1970s has been hypothesized to be one of the key factors pushing OPEC to restrict production to offset its falling revenues, triggering the first oil crisis of the 1970s (Hammes and Wills, 2005). The recent collapse in oil prices may also be a reaction of markets or producers to the strengthening of the dollar (Tokic, 2015).

Figure 5. Money flows, oil prices and the economy

In the “the dollar bloc” theory, Erceg et al. (2011) add the feature that it is not only the U.S. that depreciates as interest rates fall, but also other developing economies that have their currencies pegged to the dollar. While this does not lead to a change of the price of oil in dollars, it does lead to an increase of exports, overheating and excess demand for oil in the pegged countries (as well as in the US), increasing oil prices (T3, Fig.5) until they become so high that they cool down the economies.

Finally, a straightforward and well-known effect of low interest rates is that they stimulate economic activity. There is a case to be made that the very low rates by the Fed in the early 2000s enabled the Chinese economy and the world economy more generally to thrive, fueling the oil price boom via the demand channel (Kilian, 2008) (T4)—though causality here could also work in the opposite direction, as we’ll argue below.

One relevant question is what determines interest rates. The decisions of central banks, such as the Federal Reserve in the U.S., play a role (T5, Fig.5). But real capital flows also

matter. An alternative or rather complementary explanation is that what pushed down real interest rates in the U.S. and the rest of the world was the high rates of saving in emerging markets (T6, Fig.5). This led to a large U.S. current account deficit and the domestic housing and other bubbles. An inverse explanation would be that it was the negative trade balance faced by the U.S. since the early 1970s, and the primacy of the U.S. dollar as the global currency, that attracted foreign savings.

Caballero et al (2008) put forth a compelling 'global imbalances' story according to which oil prices started to rise notably with the destruction of safe investment assets in Asia after the 1997 Asian financial crisis. Excess savings of petro-dollars from the Arab world (T7, Fig.5) and surpluses from China and South-East Asia (T6, Fig.5) increasingly ended up in the U.S., suppressing interest rates and fueling asset bubbles, most notably in the housing sector. A positive feedback effect took hold as declining interest rates made investing in commodities like oil more attractive (T8, or through Frankel's T1, Fig.5). In turn, higher prices increased the surplus of petro-dollars in oil producing countries (T9, Fig.5), further increasing capital flows to the U.S. Quantifying the effect of oil revenues alone on the U.S. economy is impossible, but there are informed guesses that most of these petrodollars found their way directly or indirectly to the U.S., reducing interest rates (IMF, 2006). Indeed the U.S. net capital outflows from oil exporters grew by 348% between 2002 and 2006 (McKinsey, 2007 cited in Spencer et al, 2012).

By 2006, the rise in U.S. real estate prices peaked, perhaps through some combination of sectoral market forces and the Fed Funds rate rising from 1% in May 2005 to 5.26% in May 2007 (Spencer et al, 2012). With the subprime mortgage bubble broken, excess capital flowed towards the commodity market. This is the alternative explanation by Caballero et al. for the spectacular two-fold rise of oil price from 2007 to 2008, before it collapsed along with global growth and expectations. One piece of evidence that supports this story of a collapse in housing and productive assets followed by a shift to oil and commodities is that oil prices co-increased with the stock exchange market (S&P 500 index) for the 2002-2007 period, but between 2007 and 2008 oil prices continued rising while the stock exchange plummeted as the housing market collapsed. An alternative explanation of the same evidence is the one by Kilian (2014, 2008b), according to which the increase in the 2002-2007 period reflected the general demand for commodities due to a booming world economy (hence the co-movement of oil and general stock prices), while the 2008 spike was the effect of increases in the precautionary demand for oil alone, a result of feared supply restrictions.

The theories presented here complicate considerably the picture on oil and the economy, as they suggest that both oil prices and the economy may be moved by a third variable, such as interest rates or global savings and (im)balances. Other forces in turn ultimately determine these third variables. Imbalances, for example, arise from national differences in trade, development, regulation of financial markets and cross-border capital flows, or (in)equality in a given nation. Higher inequality generally produces higher surpluses and fewer investment outlets. However, even in these money-driven accounts, oil spikes require that supply must be tight: so it is always a combination of 'fundamental' and 'monetary' forces that in the end cause an actual price increase.

5. Oil, Money Markets, and Politics

Our analysis is further complicated by the fact that interest rates and oil prices have historically been negotiated, rather than market-determined, prices (Bridge and Le Billon,

2013). Such high-level negotiations are contingent upon (and influence) domestic and international politics. In some cases these prices may have been manipulated, as the recent LIBOR (interest) and Platt's (oil price) investigations show (Nocera, 2012; Scheck and Gross, 2013). More typically, they are fixed by government or quasi-governmental bodies with market power (the US Federal Reserve, OPEC). There is tentative evidence that the 1973-1974 oil hike was not a textbook market price adjustment, best analyzed by supply and demand curves, etc. (section 3). It was also not simply an "oil weapon" used by Arab nations against the West, since the vast increase in the posted price by OPEC was led by staunch US allies at the time (Iran and Saudi Arabia). Among the things producers reacted to was the falling value of the dollar (Hammes and Wills, 2005). Similarly, the price rise from 2001-2008 was a function not only of rising demand or loose monetary policy, but also of concrete production decisions made by Saudi Arabia. While domestic and international political "ecosystems," and their relationship to oil prices, are beyond the scope of this paper, it is sufficient to mention here that this "exogenous" factor—negotiated and often political prices—presents difficulties for narrower analyses. Oil produces huge value: political power is central in how this value is distributed among producers and consumers, among different nations, or among states and corporations (Bridge and Le Billon, 2013). The U.S. has followed a military option in securing its oil supply, consolidating local allies and intervening militarily when the conditions were seen as imperative (Bridge and Le Billon, 2013). A (geo)political economic approach is necessary to treat the subject of oil prices and monetary regimes in its full dimension.

For example, investigation of the antecedents of the 1973-1974 price rise, and of the subsequent economic decline in many major economies, reveals extraordinary monetary phenomena, such as the unpegging of the US dollar from gold. Varoufakis (2011) for example, provides a *long duree*, geo-economic analysis, whereby global stability and growth after World War II was secured as the global hegemon, the US, recycled its surpluses to Europe and Japan, creating growth there and outlets for its products, while keeping exchange rates stable via the gold peg. As the Vietnam War and other fiscal pressures turned the US into a deficit nation, dollars flooded dependent economies, creating inflation, devaluations, and eventually the collapse of the commitment to convert dollars to gold. This in turn helped spur the oil crisis, since as explained above the US abandoned the Bretton Woods system and the gold peg, and became a deficit nation receiving the surpluses of the rest of the world, including oil nations. Even the more historically inclined macroeconomists discussed above, such as Frankel (2008), merely allude to such events and their complex geopolitics. Many of the analysts above do not cover the historical angle at all, thus forfeiting a rich explanatory and evidentiary channel.

The control of oil has long been a tool of statecraft and military power, particularly for the US and British governments at the center of the global oil system for most of the 20th century (Mitchell, 2011). Yergin (2011) gives a history of the importance of oil both strategically and militarily, while Engler (1977) gives a detailed account of the machinations behind the first oil price shock, some involving at least tacit approval by the US. The Shah of Iran's drive for higher posted prices, for example, was supported by figures such as Henry Kissinger who wanted to back the Shah's regime, according to Saudi sources (Anderson, 1977). The Saudi rulers on the contrary were frustrated by this, concerned with the fluctuations of oil prices and the instability these endangered for their regime. Later on,

Saudi Arabia assumed the role of the world's "swing producer", expanding production and keeping prices low when markets were tight, with the U.S. "protecting" it with its military presence (and the international community turning a blind eye to the dismal human rights record of its regime).

Petrodollar recycling was one outcome of the 1970s shocks, whereby oil revenues too large to be absorbed by oil-producing countries such as Saudi Arabia and Kuwait were routed back to the US in the form of purchased government securities or large arms purchases. In a tantalizing glimpse of the linkages between global capital and oil flows, Spiro (1999) shows how the petrodollar recycling circuit was not simply a result of "markets working," but a carefully orchestrated set of political negotiations with the Saudis and others led by none other than William Simon, US Treasury secretary during the first oil shock and, significantly, the nation's first oil or energy "czar," appointed by Nixon during the crisis years. Thus in the oil shocks, money from the pockets of US consumers flowed through the oil companies to the producers of the Middle East, then back to the US Treasury, and often, from there to banks, who lent money to developing nations hurt by the spike and to global corporations. It should be remembered that these flows were often simple rents, pure margin, and were often not tightly linked to new production (as we mentioned above the intensity of exploitation by Middle East producers has remained very low since 1973). According to Spiro (1999), the petrodollar recycling arrangements engineered by the US marked the end of its period of "legitimate hegemony".

Given the dependence of many nations' budgets on their oil production, it is easy to understand the potential use of a "reverse oil weapon" that would hurt key producers by collapsing the price of oil. Indeed, a former finance minister of the Soviet Union, Yuri Gaidar, has written that it was the global price collapse in two commodities, oil and wheat, that led to the fall of the Soviet Union (Gaidar, 2007). There are repeated but still academically thin claims that the US worked with the Saudis to "open the oil tap" in 1986 precisely for this reason, i.e. to damage the Soviet Union. Some of these reports come from former Reagan administration officials themselves (Schweizer, 1994). Whatever the truth of these allegations, they have resurfaced in a new form since the 2014-2015 oil price collapse, with unsubstantiated speculations about a new orchestrated campaign against Russia—a move in the Ukrainian proxy war, perhaps a US-Western retaliation for the annexation of the Crimea.

Similar claims of economic warfare have been leveled against the US with regards to the Asian financial crisis of 1998, which as we saw above, may have indirectly spurred the commodity markets rush. In these accounts, US officials manipulated financial flows and speculative attacks against Asian markets, weakening its competitors there such as China and Japan (Gowan 1999, 93). The large holdings of dollar reserves in turn by both China and Japan since that event, which as we explained in the previous section may have contributed to the rise of commodity prices, are attributed to lessons learned from the 1998 financial crisis.

The degree to which global powers such as the US and the UK have used oil markets as strategic tools or even weapons in the examples above is uncertain. The point is that a position at the central hubs of global networks of finance and energy provides an enormous amount of power to move markets and damage rivals in the process. These maneuvers and market changes remain difficult for economists to explain via econometrics or other neat models, making the political dimension essential for analysis. Economists of course may assume that political decisions are ultimately determined by economic fundamentals and

that they are endogenous to macroeconomic conditions; but this is just that, an assumption. Power shapes the landscapes through which oil and money flow. And as these landscapes change, so do the flows they channel (Sager, 2016).

6. Lessons for ecological economics and further research

Table 1 summarises the accounts provided by different scholar communities for the key periods and events of interest. Some accounts are complementary, other diverging. Ecological Economics provides at best a very partial explanation of these events. If the core of ecological economics is the model of figure 2, then this has to be extended to include the dynamics of figures 3-5, plus the recognition that oil prices, and by extension extraction rates, are politically negotiated.

Concerning the 2008 crisis, the ecological economic explanation has to be qualified: yes, the rise in the price of oil was the result of continued economic growth in the face of a stagnating world production, as ecological economists argue, but stagnation may not have been due to a peak in the production of conventional oil, but because of strategic decisions by key producers in a context of low interest rates. Low interest rates, driven by political decisions, geopolitical dynamics and a savings glut (including the glut from petro-dollars in oil-producing nations), helped inflate oil prices and other assets in Western economies including housing. Households coping with rising energy costs increasingly borrowed, in many cases to buy houses whose prices were inflated by the savings glut and low interest rates. As oil prices kept rising due to growing demand and capital flows to the oil market, households, especially poor ones, started cutting on other expenditures, most notably cars and houses, pushing the economy toward a recession, while foreclosures in suburbs (linked to high commuting costs) brought the housing bubble to an end. With the collapse of housing assets, savings shifted to oil, increasing oil prices even more and amplifying the above dynamic.

This is a richer story than the one typically offered by ecological economists. The ecological economic theory of oil and its role in economic crisis, inspired by the work in the 1930s of chemist-turned-economist Frederick Soddy, may be summarized as follows (Martinez-Alier, 2016, Daly, 2014, Kallis et al, 2008). The economy has three levels. The base of the economy is the “real-real” economy of energy stocks and flows. The growth of the second level, that of the “real” economy of GDP, depends directly on the growth of the supply of net energy (energy returns minus energy investment). As limits are reached on the supply of net energy, with a peak in the discovery of high-EROI fossil fuels, the real economy necessarily slows down, productivity stagnating as labour substitutes for increasingly expensive energy. The third level of the economy, the virtual superstructure or the “fictitious economy” of finance and debts, can sustain the growth of the real economy in the face of limits in the real-real economy, but only for a little while. At some point, the level of indebtedness becomes too high, and “the house of cards”, to use Goodland’s (2016) opening phrase, collapses.

Event	Oil Economics	Macro Economics	Political Economy	Ecological Economics
Oil and economic crises 1973 & 1979	Growth and rising demand from developed economies (Kilian) vs. supply interruptions from events in Middle East (Hamilton).	Wrong policy response by the Fed which fearing inflation by oil prices precipitated recession by raising interest rates (Bernanke et al). US inflation and depreciation of the dollar to which OPEC responded by restricting production (Frankel).	End of Bretton Woods, US unable to finance Vietnam war un-pegged from gold and became a global importer of surpluses, “recycling” petrodollars (Varoufakis, Spiro). U.S. supported higher prices given dollar devaluation to back up Shah’s regime in Iran (Anderson, Engler).	Resource limits to growth.
Low oil prices – low growth 1985-89	Tax reform and low investment in US oil industry (Edelstein & Kilian).	-	U.S. worked with Saudis to increase oil production and damage Soviet Union (Gaidar, Schweizer)	Prices did not reflect real scarcity of oil. (No explanation about low growth)
High oil prices – high growth 2002-2007	Effect of oil prices on expenditures is cumulative and hadn’t passed the threshold where households change consumption patterns (Hamilton). Prices increased because of economic growth and industrial demand from Asia, which more than compensated for negative effects of high oil prices – the effects of a demand-driven rise of oil price take time to show (Kilian).	Independent monetary authorities responding to core inflation did not repeat mistakes of the 1970s (Blanchard & Gali, Nordhaus). Growth in oil-producing countries and in countries exporting to them overcompensated for negative effects from high oil prices (Rasmusen & Roitman). Asian savings and petrodollars flooding US, pushing interest rates down, keeping growth high and creating housing and commodity asset bubbles (Caballero et al)	Strategic underinvestment by major producers in order to maintain high prices (Smith). Petrodollars channeled from US consumers and developing countries to oil producing nations, and from them back to US Treasury and global banks and corporations (Spiro, Sager).	Resource limitations – major producers could not increase production even if they wanted Over-borrowing and credit/housing bubbles sustained household consumption and growth despite rising oil prices (Martinez-Alier)
Oil shock 2008 – Financial crisis	Rising demand from the East vs. stagnating production (Kilian, Hamilton). Reduced expenditures, esp. for cars and houses, from US households tilting economy to recession (Hamilton). Foreclosures in suburbs facing high commuting costs (Cortright, Kaufman et al).	With the subprime mortgage and housing bubble broken, Asian savings and petrodollars shifted to oil. Oil prices appreciated, while the economy collapsed because of the collapse of the housing bubble (Caballero et al).		Peak oil increased oil prices to unsustainable levels causing recession, which in turn led to the collapse of the credit/housing bubbles. (Daly, Martinez-Alier)
Slump of oil prices 2014c, limited recovery	Expectations for a growth slow-down and to a lesser extent higher global oil production (Baumeister & Kilian).	Negative effect of low prices on domestic US (shale) oil industry (Krugman). Expectations for tightened US interest rates in the near future (Frankel). Appreciation of the dollar (Tokic).	Saudi Arabia increasing production to drive US competitors out of the market.	Low EROI of the new supplies of unconventional oil? (Kerschner and Capellán-Pérez)

Table 1. Insights on the causes of key oil-economy events from different research communities

The review provided here complicates this model in at least five ways. First, while ecological economists focus on the effects of energy on production and labour productivity, the evidence is that crises are caused by reduced consumption, given a higher cost share of energy during oil price shocks. The limits in the “real-real” economy, in other words, may slow down consumption before production.

Second, the above model assumes a single economy world. In reality however high oil prices may be a drag for growth in oil-consuming countries while increasing revenues and GDP in oil-producing countries and the countries that export to them. Changes in oil prices have winners as well as losers, and the former group is not restricted to producers.

Third, it is still difficult to assert peak oil or an already biting limit in the “real-real economy”, as one can never know whether stagnating production is the result of geological limitations or of strategic decisions by producers. The discovery of shale oil, or the increase of production by Saudi Arabia after 2010, has challenged declarations of peak oil, though the quick peaking of shale deposits and low rates of conventional oil discoveries may vindicate the peak oil hypothesis in the long term.

Fourth, it is unsatisfactory to treat financial flows as a mere superstructure upon the real-real economy of resources: it is impossible to explain why and how oil prices or extraction rates and locations change without understanding the flows of money, which in turn are partly politically determined (see Figure 5, Table 1).

Fifth, and in relation to the above, there is a contradiction in so far as ecological economists tend to see in high oil prices a vindication of their predictions of peak oil, ultimate resource limits, and scarcity, but when prices are low, blame market and political forces for disguising the real underlying resource dynamics. As Norgaard (1990) argued in a fundamental contribution to ecological economics, oil prices *are not* an indicator of scarcity. They are the representation of the beliefs of market actors (and this holds true independent of whether prices are rising or falling). Our review demonstrates the complex array of political, monetary and supply-demand factors that determine oil prices—a welter of beliefs, political agencies and resource market fundamentals. It is not straightforward to infer what is happening in the “real-real” economy from changes expressed in monetary magnitudes at the “real” and “financial” levels.

Concerning the future, we identify three questions worth addressing. First, most of the current literature on oil and the economy is U.S., or at best “West”, focused. An interesting question is why growth in China (and by extension global growth) was not hampered by the oil price shock of 2008 (Bridge and Le Billon, 2013). From an ecological economics perspective one would expect a stronger effect in China, which is an industrial, energy-intensive economy, than in the service economies of the West. One potential explanation is that oil affects the economy mostly via consumption—and in China consumption is relatively lower and not as oil-intensive—yet this hypothesis requires more development.

Second, in the context of climate change, we know that a large share of current oil reserves is in principle ‘unburnable’. Nations formerly engaged actively in oil “demand construction”, through the design of car-focused infrastructures or the promotion of (sub)urbanization, now have to redesign cities and infrastructures to destroy demand (Bridge and Le Billon, 2013). Carbon taxes and other policies will deter the use of oil. How may the changing

political economy of carbon affect the price and extraction of oil, and in turn what effects might this have on different economies, as well as on the larger monetary system?

Third, the development of marginal and unconventional resources brings a qualitative change in the composition of oil supplies that is not captured in quantitative data on production or consumption (Kerschner and Capellán-Pérez, 2016). If new supplies have a declining EROI compared to old ones (and this “if” merits research on its own), then it could be that the relationship between oil and the economy changes. Increasing supplies of low EROI oil may not increase net energy and therefore may not spur economic growth. Could it be that this is the reason why the recent surge in oil supplies has not led to sustained economic recovery in the West (with the potential exception of the US)? But how could that be the case, given that oil prices are low? Is there another channel through which societal EROI affects the economy other than the manifested cost and price of energy? Ecological economists have to do more work in establishing the link between societal EROI and growth or productivity, and the channels through which it operates, proposing convincing hypotheses of why and how effects may differ among different countries with different economic structures.

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