The present research agenda focuses on the economics of sustainability associated with the transformation of energy markets. In particular, the agenda emphasizes the relevance of cross-cutting issues such as technological change and innovation in understanding the "sustainability" of energy markets, of the energy (-producing and -using) industry and of resource rich countries.

The main goal of this agenda is to contribute to a better understanding of the interrelations between technological changes and energy markets and how in turn the resulting transformations alter the sustainability of economic systems that are dependent on these markets. It also explores how innovation (or the lack thereof) understood in both a broad and narrow sense is intimately linked to the ability of resource rich economies to adapt and transform.

To the extent of our knowledge, little attention has been paid thus far to the role technological changes play in the dynamics of energy markets, and the risks and opportunities associated with the transformation of these markets. In addition, the role of innovation has been occulted from literature on the economics of resource rich countries.

Beside the relevance of these questions for academia, this research also has important policy implications for the energy (-producing and -using) industry and the ever growing number of countries that are dependent of the exploitation of energy resources.¹ Many resource rich countries have either announced or already put in place policies to help transform their economies and move away from resource dependence. The agenda has also broader relevance for the global community as it relates to the economic consequences of the needed transformation of energy markets to support the goal of limiting global warming by reducing greenhouse gas emissions.

¹ Technological change also affects commodity markets beside energy ones and in turn countries that are dependent on these commodities which markets are subject to transformation.
This agenda is structured along three lines: i) the role of technological changes in shaping energy markets ii) the understanding of the nature of the risks and opportunities associated with the transformation of these markets, and iii) the positive and normative analyses of the relationship between dependence on natural resources—with a focus on hydrocarbons—and innovation. The following three sections lay out the contours of that research.

1. Technological Change and Energy Markets

Changes in energy-producing and/or energy-using technologies can have dramatic consequences for energy markets. Technological change has implications at both the intensive and extensive margins of energy markets. In the following, we discuss a few examples.

At the intensive margin, most recently, the advent of hydraulic fracturing combined with horizontal drilling has led to the advent of so-called “shale oil” that changed the dynamic of the oil market. Indeed, shale oil will lead to shorter and more limited oil-price cycles. The rapid increase in the production of shale oil—to the tune of 5 million barrels a day (mbd) in a market of 94 mbd—has also arguably contributed to the oil supply glut that led to the collapse in oil prices that started in June 2014 (Arezki and Blanchard, 2014).

At the extensive margin, as energy-using technology evolves in the transportation sector toward wider use of hybrid and electric cars, the compartmentalization of the transport and electricity sectors is bound to disappear. Indeed, oil has thus far been used chiefly for transportation through products such as gasoline, diesel, and jet fuel. Technological change will make oil increasingly face competition from other sources of energy such as natural gas and renewables. That trend will likely benefit natural gas first and then renewables (IMF, 2016).

Technological change is, of course, endogenous to the level of energy prices or more generally to the “necessity” to innovate—as discussed further in section 3.2

2 Beyond the response of technology to oil prices, the resource base (what is known about geology as opposed to “true” geology) depends on exploration efforts. Existing evidence suggests that discoveries of oil fields (as well as other commodities) in the past decades have occurred mostly in developing countries including Latin America and Sub-Saharan Africa that were subject to no material exploration until they became more friendly to such activities. That increase in discoveries in the South is likely to continue to support supply in spite of depletion in the North and low prices (Arezki, van der Ploeg, and Toscani, 2016b).
peak-oil hypothesis posited that oil supply would top out in the mid-2000s, precisely the moment when the shale ‘revolution’ started to take off. In many respects, this revolution can be viewed as an endogenous supply response to high prices in the 2000s, hence challenging the overly pessimistic view that geological factors were to limit supply (Arezki et al. 2016b). Also, on the energy-producing technology front the expected ‘lower-for-longer’ oil price environment could delay the transition (Arezki and Obstfeld 2015).

Indeed, Aghion et al. (2016) provide evidence that firms in the auto industry tend to innovate more in “clean” (and “less” in dirty) technologies when they face higher fuel prices. Understanding the role of technological changes in energy markets is important as it potentially plays an important role behind the boom and bust cycles that has characterized these markets. The long lead time between first investment and first production in the oil sector is often put forth as a key explanation behind the boom and bust cycles in prices. The issue with that explanation is that the lead time are anticipated and hence should not trigger price change. In contrast, the precise timing with which technological changes affect energy markets is hard to anticipate in addition the consequences of these changes on supply and demand for energy are also associated with large variance.

This research will model the relevance of technological innovation and its interrelationship with price dynamics (see Arezki et al., 2016b). The research will also complement work done on the directed technological change in energy-using and energy-producing technologies in response to price dynamics and also in response to environmental policies/regulations (see Acemoglu, 2012). It will focus on the issue directed technological change in the nature of the innovation (eg. substituting fossil fuels as opposed to preserving these fuels by developing say carbon reducing technology) that has been overwhelmingly driven by fossil fuel (net) importing nations as opposed to (net) exporting nations.

From an empirical standpoint, the research will exploit the precise timing with which new innovation comes about using survey of expectations or other specialized sources used in the news shocks literature (eg. Alexopoulos and Cohen, 2009; Arezki et al. forthcoming). In determining the impact on prices one need to be cogniscent about the learning process associated the new technology, the pace of adoption and diffusion (see Leduc et al. 2013; Benabou and Gertner, 1991). The research will also explore the issue of informativeness of energy markets (Bai et al. 2013 ) in a context where innovation (and/or regulation) could turn fossil fuels into stranded assets—discussed in the next section. Specifically, it will
explore to what extent there might be a puzzle—and if so, provide explanations—associated with the risks of “strandedness” for fossil fuel companies in that these risks might not being reflected in stock market valuations.

2. The Transformation of Energy Markets, Risks and Opportunities

The energy transition (referring to the shift toward lower-carbon or carbon-free energy, such as renewables) is a source of both risks and opportunities. The risks associated with fossil fuel assets becoming stranded are likely to expose many countries to vulnerabilities (Arezki, 2017; van der Ploeg, 2016). The opportunities arising from that transition are that countries could harness the potential for relatively untapped renewable resources (Collier and Venables, 2012).

The historical COP21 agreement to keep global warming below 2 degrees Celsius and the innovation affecting energy producing and using technologies (declining cost of producing renewables; hybrid and electric cars) have further boosted the energy transition away from fossil fuels (IMF, 2016). That means that giga tons of reserves will have to stay underground unexploited. To keep mean global surface temperature below 2 degrees Celsius, only 300 to 400 giga tonnes of carbon can still be burnt but reserves of private oil and gas majors only are at least three times as high. To abide by international commitments to limit global warming a third of oil, half of gas, and 80 percent of coal reserves should be kept in the ground forever (e.g., McGlade and Ekins, 2015). This would mean keeping unburned one third of oil reserves in Canada and the Arctic, 50 percent of gas and 80 percent of coal (mainly China, Russia, US). In the Middle East, reserves are three times larger than their “carbon budget”. In other words, 260 billion barrels of oil in Middle East cannot be burnt. In addition to stranded reserves, the structures and capital used in extraction and in exploitation of fossil fuel can become stranded.

Recent giant discoveries of oil and gas (Egypt, Lebanon, Mozambique, Senegal,) are expanding the list of countries that are faced with risk of stranded assets and capital (Arezki et al. 2016a). It is hard to reconcile this trend with the objective that planetary warming has to stay below 2 degrees Celsius. Nonetheless, the large number of countries that are increasingly exposed to stranded assets make it a priority for governments and corporation to communicate and help adapt and mitigate these risks.
One implication of the spectre of stranded asset is that it could lead to a race to burn the last ton of carbon. That could in turn lead to the so-called green paradox whereby regulation aiming to limit carbon emissions end up raising the latter at least in the short run (van der Ploeg, 2010). Some commentators have argued the collapse in oil prices and deliberate attempt on the part of major oil exporters with low marginal cost of production crowd out higher marginal cost producers but also to delay the energy transition (Arezki and Obstfeld, 2015; Aghion and al. 2016).

While the risk of stranded assets for fossil fuel exporters appear to be remote, it does pose an existential threat that authorities cannot afford to ignore. The research will further attempt to quantify the phenomena using novel sources of data on natural capital and quantification methods. As mentioned above, it will also explore the extent to which financial markets can inform us about the risk of stranded assets and if not, why.

The energy transition also present opportunities including for the countries exposed to the risk of stranded assets. Solar power concentration is highest in the Middle East and Africa and parts of Asia and the United States, according to the U.S. National Aeronautics and Space Administration. The United Arab Emirates has endorsed an ambitious target to draw 24 percent of its primary energy consumption from renewable sources by 2021. Interestingly, Morocco, the host of the United Nations Conference on Climate Change (COP22), has unveiled the first phase of a massive solar power plant in the Sahara Desert that is expected to have a combined capacity of two gigawatts by 2020, making it the single largest solar power production facility in the world. The research will also rethink the quantification of the natural capital in particular resulting from the advent of renewable resources as growing source of energy. It will also explore the complementarities between these resources and other forms of capital such as infrastructure, human capital and soft capital/institutions (Collier and Venables, 2012).
3. Innovation and Natural Resources

Many fossil fuel exporters have been concerned with the need to diversify their economies. Very few have however successfully moved away from their dependence on fossil fuel (Venables, 2016). The regulatory and technological change sweeping the energy market may make it a more urgent priority. Countries and corporations reliant on these markets have to formulate policies to address risks and embrace opportunities presented by these transformations.

The adage that states that “necessity is the mother of invention" seems to have a particular resonance when considering the need to develop economic systems that are resilient to the transformation facing energy markets. The literature on the so-called resource curse has emphasized the role of institutions to help address the challenges faced by resource rich countries such as the Dutch disease, volatility, excessive spending and indebtedness (Frankel, 2012). The research will provide a novel perspective on the relevance of innovation—understood in a broad sense that is openness to new ideas but also the ability to formulate creative solutions/policies—to address the challenges these countries are faced with.

The research will explore to what extent the abundance of resources tends to direct the technological change toward the capital intensive activity of exploration and extraction and hence further the specialization of these economies (see Acemoglu, 2002). The research agenda is to explore the role of state capacity and institutions to ensure “sustainability" of economic systems. While the evidence suggest that market orientation allow exploration and discoveries of new resources (Arezki et al. 2016b), less work has been done to explore how the exploitation of resources (efficient production) is affected by state capacity. The ability or willingness of the state to innovate might also in turn influenced by the resource richness and the nature of the broader institutional framework—affecting the structure of ownership of resources and the extent of patronage spending.

From a behavioral standpoint, the research will explore the relationship between individuals’ (and possibly corporations) attitude toward innovation and resource richness using global survey data. It will attempt to explore how institutional factors help explain differences between resource rich countries in terms of attitude toward innovation or
openness to new ideas. This behavioral approach will allow to present new evidence on how resources, institutions affect incentives.

References


International Monetary Fund, 2016. Special Feature: Commodity Market Developments and Forecasts, with a Focus on the Energy Transition in an Era of Low Fossil Fuel Prices April World Economic Outlook.


