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Economic Freedom and the CO₂ Kuznets Curve

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Abstract: Politicians and international organisations advocate for increased regulation and government control of industry in order to handle climate change and reduce overall greenhouse gas emissions. However, it remains an open question how economic freedom is associated with environmental damage and whether deregulation is harmful to the environment or incentivises the use of green technology. On one hand, more government control and regulation may force firms and individuals to reduce their emissions. On the other hand, more economic freedom is likely to enable innovation and the adoption of green technological development. In this paper, I therefore combine data on growth in greenhouse gas emissions and GDP per capita with the Fraser Institute's Economic Freedom of the World indices in order to test if economic freedom affects emissions. I do so in the context of estimating a standard Environmental Kuznets Curve in which economic freedom can both reduce overall levels as well as shift the shape of the curve. The results suggest that economic freedom reduces greenhouse gas emissions but also shifts the top point of the Kuznets Curve to the left. Part of this effect may be due to the effect of economic freedom on the adoption of renewable energy.

Keywords: economic freedom, environmental performance, greenhouse gases, Kuznets Curves

JEL Codes: H23, O31, P16, Q55

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1. Introduction

One of the most important and politically controversial questions today is whether economic growth and environmental sustainability are inescapably in conflict with each other, or if further growth and productivity improvements are necessary to solve global environmental problems. While many economists including the Nobel prize recipient Paul Romer remain optimistic with respect to the ability of market economies to deal with climate change and environmental problems, many others including leading members of the United Nations' IPCC panel and the Swedish activist Greta Thunberg passionately argue against free markets and in favour of draconic political measures.

Politics aside, it remains an open question if societies characterised by economic freedom are associated with more environmental damage. On one hand, more government control and regulation could in principle force firms and individuals to reduce pollution, environmental damage and their CO₂ emissions. On the other hand, more economic freedom is likely to enable innovation and incentivise the adoption of green technological development. Whether free markets create environmental damage or enable societies to find and implement solutions to such problems is an empirical question.

In this paper, I therefore combine data on growth in CO₂ emissions and GDP per capita with the Fraser Institute's Economic Freedom of the World indices in order to test if economic freedom affects emissions. I do so by estimating a standard Environmental Kuznets Curve (EKC) in which economic freedom can both reduce overall levels as well as shift the shape of the curve. The EKC describes how the size and scope of environmental problems changes during the course of economic development (Dasgupta et al., 2002; Shahbaz and Sinha, 2019). The main innovation in this paper therefore is that the empirical framework not only yields estimates of pure level effects of economic freedom (cf. Lundström and Carlsson, 2003; Adesina and Mwamba, 2019), but also allows me to assess the degree to which the quality and timing of environmental transitions depend on economic freedom.

The available data from 155 countries observed in five-year periods between 1975 and 2015 indicate that economic freedom not only reduces overall CO₂ emissions but also shifts the top point of the EKC to the left. As such, the evidence suggests that the transition to lower emissions technology appears at an earlier stage in economically free societies.

The rest of the paper is structured as follows. Section 2 outlines the theoretical considerations in favour of and against intervention and state control. Section 3 describes the data and the empirical strategy used in Section 4. Section 5 discusses the results and concludes.

2. Theoretical considerations and previous literature

Considering the theoretical association between the degree of government intervention and control and emissions of greenhouse gases – and thus between economic freedom and emission dynamics – one has to navigate conflicting mechanisms and concepts of government.¹ In the following, I outline the most important *dynamic* theoretical arguments for and against government intervention and control. Particularly, I distinguish between static arguments that deal with the best allocation of given resources and use of known technology and dynamic arguments resting on the speed with which an economy changes its use of resources and develops or adapts new and previously unknown or unused technology.

2.1. Arguments in favour of state control: Neoclassical economics

Some of the arguments in favour of state control and intervention rest on the neoclassical argument popularised by public economics that pollution problems, and particularly problems of air pollution, are essentially problems of negative externalities (cf. Barr, 2012). The problems of externalities have been known since Pigou's (1932) seminal work, who argued that an unregulated market would produce too high emissions. However, the argument is not only about the static properties of a free market economy, but also about its dynamic development. A modern version of Pigou's argument that the private costs of emissions are lower than the true social costs implies that private firms in a market economy have reduced, sub-optimal incentives to invest in low-emissions technology because they do not bear the full costs of their emissions. Similarly, Stern (2008) argues that regulations can speed up innovative activity by allowing firms to exploit economies of scale and providing regulatory certainty to the relevant industries.

As such, negative externalities may hold back innovative investments needed to reduce CO₂ emissions and other types of pollution. A similar externality argument is often made for innovative investments and investments in research and development in general. First, when firms cannot prevent other firms from appropriating their technology and innovations, the profit motive behind investing such technology and the supernormal profits necessary to recoup the often highly risky investments disappear. These problems may require government action such as general support for basic research, research subsidies and tax exemptions for certain types of investments, and the allocation of patent rights (Griliche, 1986; Jones and Williams, 1998; Stern, 2008). Second, in the

¹ It must be emphasized that this is not a paper on the EKC *in general*. Instead, it is specifically focused on the role of economic freedom. The EKC for greenhouse gas emissions, its methodological challenges and the particularly mixed findings are surveyed in Shahbaz and Sinha (2019).

case of non-innovative firms, they may also lack the absorptive capacity to implement new technology as emphasised in the literature on foreign direct investments (cf. Borensztein et al., 1998). Given such problems, a case can be made for government-mandated and possible also government-funded education and vocational training to overcome the problem, if it is endemic to most firms.

Third, as emphasised by Munger (2008), private firms as well as individual voters may lack information on the extent of the problems as well as possible solutions and new technology. Specialised knowledge may require particular expertise that many firms do not have, and information on new technology and knowledge may be proprietary. Both problems will lead to reduced adoption of clean technology while a lack of information among voters and consumers may both affect their political behaviour and the extent to which they reward firms or products that are perceived to be less resource-intensive or produced in a ‘cleaner’ way.² As such, publically provided information campaigns and information banks may be necessary to overcome these types of problems.

Finally, credit constraints can prevent firms from taking potentially profitable, but risky investments. Large-scale innovative activity as well as wholesale implementation of clean technology constitute large bulk investments, which may be beyond the scope of many firms due to either credit constraints that may make it impossible for firms to finance the investments or owing to high transition costs. This may require government coordination of an entire industry, government-run or government-mandated national development banks that provide loans to innovative activities and, in the present case, to investments in the development and implementation of clean / green technology, or public regulation and subsidisation of financial institutions in order to provide sufficient loans. Firms may also be helped by the adoption of green public procurement rules that help create larger markets for low-emissions technology.

2.2. Arguments in favour of state control: Heterodox and Marxist economics

However, a number of scientists and political commentators maintain that such arguments from standard neoclassical economics and public economics are far from sufficient to characterise the entire problem. Their additional arguments and theorising are sometimes characterised as

² However, a further problem is when there is disagreement about facts. A pertinent example occurred in the spring of 2019 when a study from the prestigious CESifo Institute in Munich found that the life-cycle carbon footprint of a popular electric car can exceed that of a similar-sized Mercedes Benz diesel car (Buchal et al., 2019: The study was attacked by the German car industry as well as interests within the renewable energy sector (*die Forschungsgesellschaft für Energiewirtschaft* and *Agora Energiewende*) and fiercely debated in the German media.

‘heterodox economics’ although the arguments range from variations on standard welfare economics to full-blown Marxist analysis.

A common feature of these arguments is that they all rest on claims that there are fundamental problems with a free market economy that prevent any market-conform policies from being effective. A common claim underlying many such arguments is that a capitalist economy is inherently characterised by short time horizons / high discount rates in economic decision-making and thus also short effective time horizons in investment behaviour. The short time horizons create problems equivalent to externalities when future costs are heavily discounted.³

A first theoretical argument for problems with inherently short time horizons – what Schulman (2019, 12) calls “the very externalities capitalism has itself generated” – comes from Marxist theory. While, as Stigler (1950) explains, modern price theory emerging from the simultaneous work of Jevons, Menger and Walras rests on the foundation that prices are reflections of subjective preferences revealed in market interactions, Marxist theorists continue to reject subjective theories of value. They instead follow either Marx’s labour theory of value or other versions of cost theories of value, which allows Marxist economists to argue that prices revealed by a free market economy are fundamentally inefficient and ought to be replaced by what is termed ‘socialist reproduction prices’.

As Laibman (2013, 504) argues, “Socialist reproduction prices result from calculation of direct plus indirect resource use by enterprises, and also embody the long-time horizons necessary if the society is to address looming ecological constraints and requirements of sustainability.” The insistence on applying the type of cost theory of value, as exemplified by Laibman, also logically implies that capitalist economies will suffer from substantial coordination problems when economic coordination rests on capitalist market prices (cf. Hayek, 1945). Modern Marxists thus argue that capitalist economies not only are ecologically unsound, but also fundamentally unproductive.⁴

³ A somewhat peculiar problem is that if economic actors *in general* suffer from short time horizons, then they will apply the same preferences when acting as voters. Unless one makes asymmetrical behavioural assumptions, voters will thus have short time horizons that they force upon political decision-making, which implies that one cannot leave the question of how to deal with environmental problems to democratic decisions.

⁴ It should be noted that although many modern Marxist economists continue to rely on cost theories of value, Oscar Lange’s response to the Austrian challenge to socialist thinking was more advanced. Lange (1947b, 125) invoked Pigou’s then new theory of externalities by arguing that in a capitalist economy, “Most important alternatives, like life, security, and health of the workers, are sacrificed without being accounted for as a cost of production. A socialist economy would be able to put all the alternatives into its economic accounting.” He thus combines the use of subjectivist value theory with arguments for substantial and endemic externalities to argue for the superiority of

However, another argument that does not rest on Marxist thinking but still claims that a free market economy entails time discount rates that are substantially higher than optimal rests on ethical considerations. This is the approach taken by the much-discussed Stern Review – a report on climate change and climate policy commissioned by the British government – in which Nicholas Stern applies ethical considerations in favour of a much lower discount rate than what follows from most standard economic studies (Stern, 2007a). Stern (2007b, 8) argues that any application of standard estimates of individuals’ discount rates “involves discrimination between individuals by date of birth,” and claims that fundamental ethical considerations of intergenerational neutrality logically require the use of a discount rate close to zero. Stern thus arrives at very similar policy implications as Marxist thinkers, although from a very different theoretical starting point.⁵ In both cases, the implication is that the intervention and control by both national governments and institutions of global governance are necessary, as free market economies in their view are unable to deal with environmental problems in general and cross-border externalities in particular.

Finally, an alternative and quite different argument derives from the politically influential work by Mazzucato (2013). Contrary to standard approaches to supporting basic research (Griliche, 1986; Jones and Williams, 1998), Mazzucato argues in favour of direct government control of the allocation of entrepreneurial resources and activity. Her argument rests on two main claims: 1) that a free market economy rewards so-called “value extractors” more highly than value creators; and 2) that firms such as large financial corporations, high-tech corporations and the pharmaceutical industry are value extractors that capitalise on the innovation created by state research agencies and public universities – the value creators.⁶ Combining these assertions, Mazzucato claims that most successful technical innovations the last 60 years have been the results of government-run research, and not any form of private or market-driven activities.

organising the economy along socialist lines. In an appendix about the allocation of resources to his two-part article on the viability of a socialist economy, Lange (1937b) lays out the case while chastising fellow socialists for sticking to Marx’s labour theory of value. In the same line of work, Lange maintained his insistence on citizens’ full freedom of consumption, which he tried to make compatible with the top-down organisation of a socialist economy.

⁵ Many economists, vividly represented by the later Nobel Prize recipient William Nordhaus, have been highly critical of the *Stern Review*’s near-zero discount rate. Nordhaus (2007a, 688) is particularly scathing, calling the review a “thicket of vaguely connected analyses and reports on the many facets of the economics and science of global warming” and criticising Stern’s radical policy proposals.

⁶ Mazzucato (2013) further claims that when the former are effectively exploited by the latter in a capitalist society, the result is growing income inequality. This secondary claim has probably contributed to her popularity on the left wing of many Western societies.

Mazzucato's main argument rests on the assertion that when value is conceptualised as the price a good, service or innovation can fetch in a free market, capitalists can enrich themselves by manipulating prices and thereby becoming rich without contributing actual 'value' to society. She views this type of behaviour as a market failure to be alleviated by government such that the entrepreneurial talent currently flowing into value extraction is redirected to innovation and contributions to sustainable growth. While her argument thus is laid out as a market failure problem, it rests on a non-subjective theory of value, and thus a similar concept of value and prices as used in Marxist theory. It follows that the price of and value to society of innovative activities, as well as the pricing of pollution and CO₂ emissions cannot be gauged from market activity, but must be assessed differently by government.

Mazzucato (2013) is hence one of several academics to propose the creation of a government-owned National Investment Bank to fund innovative activity and a transition to a sustainable low-carbon society.⁷ The implications of her theoretical considerations and examples is that private firms are rarely innovative and resources should flow to government-run or government-mandated research and development activities. In order to further innovative activity, Mazzucato requests a substantial expansion of government spending and government control of large parts of the economy. Such implications are echoed by many other academics who share her theoretical starting point and her conceptualisation of value to society. Grace Blakeley (2019), a Marxist economist at the Institute for Public Policy Research, exemplifies this view of optimal policy by describing what is needed as "democratic public ownership over most of the economy, dramatic increases in state spending, and the controls on capital mobility required to achieve this." Interestingly, she as well as many other economist within this tradition thus seems to recognise that most private firms would move their activities out of a country that implemented her policies without also implementing capital controls practically equivalent to expropriation. All of these arguments can be subsumed as calls for very substantial reductions in economic freedom as a way – and arguably the only way – to further a transition towards lower CO₂ emissions and less pollution.

Overall, a variety of arguments exist from market conform regulations and supplementary government funding for basic research to calls for a full-blown autocratic Marxist economy. However, an even larger number of arguments exist in favour of the effectiveness of a free market economy to which I now turn.

⁷ Mazzucato's ideas have been so influential that the European Union's Horizon Europe program, a 100 billion euro research and innovation program, includes several of her policy ideas.

2.3. Arguments against state control: Knowledge in the Austrian tradition

In order to outline the arguments in favour of a free market economy contrary to extensive government intervention, a natural starting point is what is known as the socialist calculation debate of the 1930s. I will subsequently turn to the related incentive problem as laid out by the public choice school of thought.

The knowledge problem in political decision-making and bureaucratic processes was first described by von Mises (1920, 1944) and Hayek (1937). In insights originally developed by von Mises (1920), the emerging Austrian school of economics first came to emphasise what is known as the ‘local knowledge problem’.⁸ While proponents of interventionist approaches implicitly assumed (and continue to assume) that all relevant knowledge is already known or knowable and available to planners, a large share of the data required for rational economic planning is distributed among individual actors and thus unavoidably exists outside the knowledge of a central authority. While Lange (1937a, 55) had argued that “The administrators of a socialist economy will have exactly the same knowledge, or lack of knowledge, of the production functions as the capitalist entrepreneurs have”, Hayek (1945, 519) later noted in his seminal work on the use of knowledge in society that:

If we possess all the relevant information, if we can start out from a given system of preferences, and if we command complete knowledge of available means, the problem which remains is purely one of logic. That is, the answer to the question of what is the best use of our available means is implicit in our assumptions. This, however, is emphatically not the economic problem which society faces. And the economic calculus which we have developed to solve this logical problem, though an important step toward the solution of the economic problem of society, does not yet provide an answer to it. The reason for this is that the “data” from which the economic calculus starts are never for the whole society “given” to a single mind which could work out the implications and can never be so given.

In the context of government regulation, no bureaucrat can therefore ever know all the relevant particulars necessary to devise, implement and enforce regulations or direct government control of parts of the economy. While some information about the technology and production processes applied in private firms may be available, although at a considerable cost, these

⁸ Much of the thinking in welfare economics and most particularly in heterodox and Marxist theories are associated with a French positivist tradition in which it is possible to provide a sufficient solution to any problem through a theoretical analysis (Hazareesingh, 2015). These contributions thus mostly rest on purely deductive reasoning that is often anti-empirical. It is thus ironic that some modern strands of Austrian economics are equally critical of virtually all empirical work.

characteristics are likely to change over time. In other words, bureaucrats must dynamically adjust regulatory policies, as they are aiming for a moving target. Yet, much knowledge at the firm level – and in particular knowledge related to innovation activity and entrepreneurial tasks – is also likely to be tacit and thus not codifiable. These problems creates the situation known as ‘Hayek’s Institutional Design Problem’ in which the bureaucracy and political decision-makers do not only lack sufficient unbiased information with which to design regulatory policy, but where firm behaviour is affected by the regulatory framework (Munger, 2008). As regulation changes firm behaviour, information about firm behaviour in the absence of regulation and thus information about the very market failure or other problems that regulatory policy is supposed to solve is destroyed by the regulatory policy itself.

In addition, the process of bureaucracy does not allow for the type of learning through empirical trial and error that is necessary to *reveal* what works and what does not (Stigler, 1971). The knowledge problem also represents a massive problem for any attempt at substantial policy coordination and not just the implementation of single interventions (Greenwood, 2015). In a dynamic context, these problems are specifically problematic, as one cannot predict *ex ante* which new technologies, innovations and changes to production processes that work better or lead to cleaner outcomes and lower emissions. As Hodgson (1999) emphasises, the type of trial and error learning that is inherent in any form of research and development requires structural ‘impurities’ in the economy in the form of multiple types of production and organisation, and a dynamic market economy to reveal which new forms may be superior to other forms.

Some of these structural impurities are created by entrepreneurial activity when entrepreneurs particularly alert to yet undiscovered opportunities experiment with changes to products, production processes, management procedures and other innovative behaviour (Kirzner, 1973). More pertinently to the present discussion, in Schumpeter’s (1943, 132) conception of entrepreneurs, their role in the economy is “to reform or revolutionise the pattern of production by exploiting an invention or, more generally, an untried technological possibility...” As Ricketts (1992) emphasises, this is a much more encompassing and demanding role than mere alertness, but also one that is central to the dynamic development of society as entrepreneurs alleviate the particular problem of Knightian uncertainty – of the nature of future technology and innovation as an unknown unknown (Knight, 1921).

In many instances, Kirznerian and Schumpeterian entrepreneurs thus *react* to market failures as such failures represent profit opportunities not yet exploited by other actors. Similarly, entrepreneurs will react to increasing prices of specific resources by investing in resource-saving technology and in developing substitutes to the scarce resource (Simon, 1981). In the context of

all dynamic development, and not least resource-saving and low-emissions innovation, such entrepreneurial activity is an important private mechanism with which societies become more productive and less dependent on specific resources. Yet, as a growing literature has documented in recent years, it is in general economically free countries that generate more entrepreneurial activity and thereby become more productive (cf. Bjørnskov and Foss, 2016). In other words, empirical evidence suggests that more government control, more government production and regulatory intervention is associated with substantially *slower* dynamic development of the kind necessary to reduce pollution and the emission of CO₂ and other greenhouse gases.

As originally conceived by Mises (1920) and Hayek (1937), the lack of knowledge – through the inability of bureaucracies to access the dispersed knowledge of millions of private firms and decision-makers as well as the impossibility of accessing knowledge about future technology and opportunities and thus of any knowledge about dynamic opportunities – implies that government interventions, regulation and control are not likely to be viable long-run solutions to environmental problems. However, even if such problems could be solved, as claimed in sections 2.1 and 2.2, the incentive structures of political and bureaucratic decision-making may prevent such solutions from being viable. This is the last theoretical problem, which I now turn to.

2.4. Arguments against state control: Incentives and problems of public choice

A final line of arguing comes from public choice and focuses on incentive problems in politics and the bureaucracy. A long line of research since Buchanan and Tullock's (1962) seminal work has documented that while there are market failures, there are also frequent and entirely predictable government failures that one has to take into account.

First, the public choice approach questions whether all problems of adverse firm behaviour are due to market failures. Reflecting the main question in this line of research, Keech and Munger (2015) argue that many situations that are regularly diagnosed as market failures are in reality government failures because governments shape the formal institutions, which define the incentive structure of private firms and citizens. A standard neoclassical prescription is, as emphasised above, to allocate and enforce patent rights, thereby giving private firms the economic incentives to invest in risky innovate activities and plan on a long time horizon. Yet, if the political incentives of government are inconsistent with the existence of an effective and politically independent judiciary that can enforce such rights, *de jure* patent rights and more general protection of private property rights are unlikely to yield private incentives to invest (cf. Aidt et al., 2018; Bjørnskov, 2018).

Second, a similar problem can be created when governments' electoral support either changes or implies a premium on visible political activism. The institutional and regulatory uncertainty created by frequent policy changes, many of which are difficult to forecast, implies that private firms come to operate with effectively short time horizons. As documented by Baker et al. (2016), substantial policy uncertainty lead many private firms to either postpone or entirely cancel many investments and may lead them to plan on a shorter time horizon. The short time horizons and heavy discounting of the future that Marxist and heterodox approaches claim to be market failures or inherent features of a free market economy may therefore be the results of government failures, and thus a reflection of the diametrically opposite institutional situation.

As such, research within the public choice tradition emphasises that the private incentives of politicians and bureaucrats are at least as problematic as the private incentives of firm owners, and are in many cases the origin of negative externalities. Some of these incentives derive from the desire to be re-elected or stay in power through other means and thus from what Keech and Munger (2016) categorise as “procedural failures” that can cause collective decisions to be unpredictable, arbitrary and occasionally manipulated. Another type of political incentive with similar problems derives from corruption, lobbying and other types of rent seeking, which Keech and Munger term “substantive failures.”

The latter type of public choice problems have the potential of undermining the effectiveness of government action, even if one ignores the Austrian emphasis on knowledge problems. As noted by Olson (1965), organised special interests can often exert substantial influence over policies and institutional choices by providing campaign funding and other political support in return of policy in favour of the interests. These interests may be private firms and non-government organisations as well as labour unions trying to protect jobs for union members.⁹ Moreover, Hillman (1982) shows that firms in declining industries have stronger incentives to rent-seek than firms in more profitable sectors. Less productive, resource-intensive and older firms are thus both more interested and often better positioned to seek rents while younger, more productive and resource-efficient firms are likely to be less interested and not sufficiently connected to do so. As such, special interest politics will most often favour industry incumbents and less productive sectors, and thus most likely also firms competing with modern, low-pollution and low-emissions industry (cf. Grossman and Helpman, 2001). These firms typically use political influence to gain protection from international trade and foreign direct investments that often bring new and more environmentally friendly technology (Demena and Afesorgbor, 2020). While

⁹ The latter case can exacerbate insider-outsider problems where unions create unemployment by only negotiation wages and labour contracts for those already in the labour market (Lindbeck and Snower, 2001).

the type of industrial policy advocated by both some neoclassical economists as well as political advisors such as Mariana Mazzucato may in principle be well intended, it is almost always *de facto* problematic and counter-innovative.

A related problem is that Hayek's institutional design problem is not only created by government, such that the very act of attempting to regulate private behaviour implies that government loses the ability to effectively alleviate environmental problems, even if all relevant political actors are benevolent (Munger, 2008). Laffont and Tirole (1991) use monopoly regulation as an example with which to show how informational asymmetries not only prevent government from regulating firms efficiently, but can incentivise regulatory capture. The information, which bureaucratic regulators need to implement and enforce regulations, must under many circumstances come from regulated industries themselves. This implies, as Stigler (1971) originally noticed, that firms and industries that are supposed to be regulated can affect the regulations through the information they supply, as well as through more regular and potentially corrupt rent-seeking associations with the bureaucracy (Treisman, 2000; Kingston, 2007).

In addition, although it is usually assumed that the influence runs from firms to politicians, McChesney (1987) argues that policy-makers may actively create rents, for example in the form of particular political privileges, in order to extract funding and privileges from industry. This complex of problems of political rent-seeking and regulatory capture often benefits incumbents and keep new and potentially innovative firms out of the market (cf. Bradley and Klein, 2016; Tollison, 2012). Many studies thus find that the regulatory burden on regular firms is most likely above the optimum and regulations in the long run exert sclerotic effects on investments (Coates et al., 2010; Heckelman and Wilson, 2019). Such problems multiply in case government takes over industry itself in the form of either direct nationalisation or through extensive political regulation, as attempts to avoid rent seeking through such means risk creating government monopolies with no incentives to economise on resources – a situation that was painfully obvious in communist countries (Bjørnskov, 2018).

Overall, claims of a 'climate crisis' and similar arguments may thus be convenient justifications of substantially increased political control and a much larger role for specific international or national organisations in politics and society. In other words, some politicians may have strong incentives to piggyback increased overall political control of the economy onto standard environmental policy, which may be an effective way of reducing the electoral resistance to such control while benefitting special interests. As such, both the left and right in politics have interests in such regulation and weakened institutions. Although politicians and political parties occasionally blame each other, industrial special interests more politically aligned with right-wing

parties may lobby for regulation to artificially protect their profitability just as it may be a specific left-wing project under the influence of labour unions to protect jobs in traditional sectors (cf. Aidt et al., 2018).

2.5. The overall pattern

In total, the full theoretical picture is distinctly muddled. It is possible to find theoretical arguments in order to defend almost any position on whether an economically free market economy or a state-controlled and politically regulated society are preferable. Yet, regardless of one's position, one would ideally want a political-economic system that places minimal epistemic demands on politicians and civil servants designing environmental policy. One would presumably also strongly prefer politically independent judiciaries and bureaucracies and effective constitutional limits on policy-making in order to avoid public choice problems (Buchanan and Tullock, 1962). How close the typical situation in most years is to such an ideal, and to which extent economic freedom is associated with dynamic development towards a low-emissions economy is eventually an empirical question, which I address in the rest of the paper.

3. Data and estimation strategy

While there are many dimensions to the debate about pollution, climate change and emissions, most political discussions – and certainly some of the fiercest discussions – centre on countries' emissions of CO₂. I therefore focus on the development over time in (the logarithm to) emissions of CO₂, measure in kilotons per inhabitant, which I derive from the World Development Indicators database (World Bank, 2019). From the same source, I derive data on the emissions of total greenhouse gases (which also includes all anthropogenic CH₄ sources, N₂O sources and F-gases) and the percent of all energy consumption that is renewable energy. I employ the latter variable in order to test if part of the development is associated with changes in the way energy is produced.

In the choice of the main policy variable, I follow a long literature in employing the Economic Freedom of the World (EFW) dataset, which is published annually by the Fraser Institute (Gwartney et al., 2019).¹⁰ Economic freedom is defined on the basis of the belief that all “individuals have a right to choose – to decide how to use their time and talents to shape their lives” such that they are “economically free when they are permitted to choose for themselves and

¹⁰ Although the Fraser Institute is responsible for publishing the data and the annual report, the data is maintained by a collaboration between researchers at Florida State University, Southern Methodist University and West Virginia University. Hall and Lawson (2014) survey the large literature that has used the EFW data.

engage in voluntary transactions as long as they do not harm the person or property of others. [...] economically free individuals will be permitted to decide for themselves rather than having options imposed on them by the political process or the use of violence, theft, or fraud by others.” (Gwartney et al., 2019, 1). The EFW index is therefore the most frequently used measure of the degree to which a society can be characterised as having a free market economy. The entire index, which is measured on a scale from 0 to 1, can be broken down into its five constituent parts: Size of government, Legal system and property rights, Sound money, Freedom to trade internationally, and Regulation. I follow a long series of studies in both testing the effects of the overall index as well as breaking it down into three parts, consisting of size of government, legal quality, and policy quality, which is an average of sound money, freedom to trade, and regulation. This may be important, as the size of government in particular is only weakly correlated with the remaining elements of the EFW index and legal quality is known to be particularly important, but the least changeable over time (Heckelman and Stroup, 2005; Sobel and Coyne, 2011; Rode and Coll, 2012).

In order to estimate an Environmental Kuznets Curve (cf. Dasgupta et al., 2002), I employ data on the logarithm to real, purchasing-power adjusted GDP per capita and its square from the Penn World Tables, Mark 9.1 (Feenstra et al., 2015). From the same source, I also employ the logarithm to the size of the population, as well as data on the total volume of trade in manufactured goods, as percent of GDP (cf. Rafiq et al., 2016). I keep the specification as parsimonious as possible in order not to introduce bad controls, as well as not to require additional data that would substantially reduce the sample size.¹¹

The combination of these data yields an unbalanced panel of up to 155 countries observed in consecutive, non-overlapping five-year periods beginning in 1975 and ending in 2015; all data are summarised in Table 1. When restricting the sample to democratic observations, as defined by the minimalistic, dichotomous indicator in Bjørnskov and Rode (2020), this is reduced to 103 countries. With these data, I estimate an EKC, i.e. the effect of the logarithm to GDP per capita and its square, using a standard OLS estimator with period and country fixed effects.¹² As both

¹¹ Ideally, one would include measures of the type of energy policy, energy taxes and subsidies, and specific regulations, as well as a number of other specific factors. However, the availability of such data is very limited and their inclusion is therefore infeasible. Bad controls would, for example, include production types of energy and levels of technology, as economic freedom could arguably make specific types more profitable and thus affect the emissions of greenhouse gases.

¹² Throughout the paper, I refer to effects and use causal language. While it may be possible that the emissions of greenhouse gases could affect single economies in the long run, it appears highly unlikely that they affect the level of economic freedom or reflect factors that might. Even the IPCC (2014) assesses that the global income loss of unmitigated climate change is a few percent over a period of 80 years.

CO₂ emissions and GDP per capita are measured in logs, the estimates can be interpreted as quasi-elasticities. In subsequent tests, in addition to entering the EFW index as a linear control variable, I also interact it with the Kuznet Curve, that is, with the logarithm to GDP per capita and its square. As such, these tests allow for estimating the central question of this paper: whether economic freedom affects the *transition* towards a low-emissions economy, which would be observable as a shift in the shape and position of the Kuznets curve. I do so using both the full EFW index as well as three decomposed factors, which informs about which of the many theoretically possible mechanisms may exist and be particularly strong.

Insert Table 1 about here

4. Results

Before turning to the estimates, Figure 1 provides an impression of the data. The figure plots the change in CO₂ emissions per capita between 1990 and 2015 for countries in four equally sized groups: the quartile of countries with the lowest average EFW index across the period, the second quartile (the low-mid EFW), the third quartile (the mid-high EFW), and the quartile with the highest average level of economic freedom during the 25-year period.

Insert Figure 1 about here

The figure clearly illustrates how the third and fourth quartiles differ from the rest. In the former group, which includes economically successful lower and middle-income countries such as Botswana, Cape Verde, Mexico and South Africa, emissions on average increased by almost an entire tonne per capita. In the latter group, that for example includes Denmark, the United Kingdom, and Singapore, but also middle-income countries like Chile, Costa Rica and Panama, emissions decreased by on average .7 tonnes of CO₂. While performance in the third quartile is very diverse and its emissions development is only statistically weakly worse than performance in the first and second quartiles ($p < .09$), the fourth quartile is substantially and significantly different from the other groups ($p < .01$). As such, the simple long-run profiles exemplified in Figure 1 indicate that a CO₂ Kuznets Curve may exist and depend on the level of economic freedom.

4.1. Main results

With these simple differences in mind, I next proceed to the formal estimates, beginning with the simple, linear tests in Table 2. Overall, the estimates suggest that population growth leads to higher CO₂ emissions per capita, although this effects appears driven by the inclusion of autocracies in columns 1 and 2. The results also suggest no clear, general effects of economic freedom. Conversely, while the estimates of GDP and GDP squared provide evidence of an EKC, a glance

at the four sets of estimates makes it obvious that there is substantially more curvature in the democratic subsample. Yet, the estimates in column 4, which excludes both autocracies and the ten largest oil producers in the sample, still imply an average turning point of the EKC of approximately 85,000 USD per capita. In other words, only the very richest societies in the world appear to be at a point of economic development at which their emissions begin to decrease.

Insert Table 2 about here

However, the linear estimate of economic freedom in Table 2 is only likely to capture static effects of changing policies consistent with a status of economic freedom. Yet, arguments both against and in favour of freedom in section 2 suggest that its effects are dynamic, i.e. that economic freedom affects the transition patterns inherent in any Kuznets Curve. In Table 3, I therefore interact economic freedom with GDP and GDP squared, and thereby allow it to affect the shape and position of the curve.

Insert Table 3 about here

The main results in the table must be interpreted with care, as the estimates of both GDP, GDP squared and economic freedom cannot be interpreted on their own, but only as conditional estimates (Brambor et al., 2006). However, the interactions indicate that for each point of change in economic freedom, both the upward and downward sloping parts of the CO₂ Kuznets become steeper. They also indicate that the top point of the curve – i.e. the level of economic development at which point emissions typically start to decrease – occurs significantly earlier the higher is the level of economic freedom.

In other words, economic freedom both implies more curvature and shifts the EKC to the left.¹³ Evaluated at a level of economic freedom of 8, i.e. for the approximately ten percent freest countries in recent years, the estimates imply a turning point at about 63,000 USD and a point at which GDP is no longer significantly positive at approximately 35,000 USD. Figure 2 illustrates the main difference by depicting the marginal effect of increasing GDP per capita, evaluated around the 90th percentile of the EFW index, i.e. at high economic freedom, and at the low level of the 10th percentile. The figure shows how, despite starting at a higher impact of economic development, the marginal effects of development decrease substantially faster in an economically free society. Figure 3 depicts the same pattern in a different way by plotting the two Kuznets Curves implied by the estimates.

¹³ Interpreting the estimates symmetrically, as recommended by Brambor et al. (2006), they also suggest that the effect of economic freedom *per se* becomes significantly negative above a GDP level of approximately 40,000 USD. Using the results in Table A2 specific to legal quality, this point is at about 26,000 USD while legal quality is significantly *positively* associated with CO₂ emissions at intermediate levels between 4000 and 10,000 USD.

Insert Figure 2 about here

Insert Figure 3 about here

Distinguishing between elements of the EFW index, as reported in Table A2 in the appendix, shows that these differences are not driven by the size of government, but are somewhat stronger and visibly more precisely estimated with the subcomponent that measures the quality of the legal system (cf. Rode and Coll, 2012). Using this component yields an estimated turning point of the CO₂ Kuznets Curve about 54,000 USD, corresponding to the present level of economic development of parts of Northern Europe and North America.

4.2. Economic freedom, greenhouse gases and the use of renewable energy

However, while the political focus in recent years has been on CO₂ as the leading – and occasionally only – indicator of economic effects on climate change, several other types of emissions may be relevant. In addition, parts of the transition towards a low-emissions economy that most commentators and scientists imagine is a transition towards using renewable energy instead of energy production based on the use of fossil fuels. In Table 4, I therefore use the (log to) total greenhouse gases per capita and the (log to) share of renewable energy of all energy consumption as alternative dependent variables. Columns 2 and 4 of the table exclude all autocracies and the ten largest oil and gas producers of the sample.

Insert Table 4 about here

Overall, the results are similar to those in the previous tables although larger populations consistently seem to use less renewable energy. The estimates show that the EKC for total greenhouse gases is similar to that for CO₂ alone, although with a substantially earlier turning point. The results in column 2 suggest that at high levels of economic freedom (an index of 8), the emissions of greenhouse gases in general start decreasing from a GDP level of approximately 25,000 USD. This turning point occurs at significantly higher levels of GDP the less economically free society is. The results in the right-hand side of the table confirm the existence of a general transition, as the use of renewable energy starts increasing from an income level around 26,000 USD per capita in economically very free societies, but at much higher levels of income in less free societies. It is thus also unlikely that the pattern identified in Table 3 is created by shifts away from CO₂ emissions to other greenhouse gases or towards the use of other forms of non-renewable energy that are less politically visible.¹⁴

¹⁴ Tables A3 and A4 report the results using the three components of the EFW index, as in Table A2. Similarly to the CO₂ results, the estimates suggest that effects are largest and most precisely estimated when using the component capturing legal quality, which also yields the lowest implied turning points of the curves (25,000 and 21,000 USD,

5. Conclusions

One of the most hotly discussed questions in international politics as well as most Western countries is whether and how to achieve a transition to a low-emissions society that economises on resource use and pollutes less. Unfortunately, it is a discussion where economic and political-economic theory provides no clear answers or insights. Depending on one's political beliefs and sensibilities, it is possible to pick almost any position on whether government intervention is good, bad or irrelevant for the development towards less pollution and a low-carbon economy. As argued in section 2, economic theory *per se* is not helpful.

However, employing a large panel dataset covering up to 155 countries observed in five-year periods since 1975 allows me to estimate Environmental Kuznets Curves for the emissions of CO₂, other greenhouse gases and the transition towards renewable energy, all providing clear results. Allowing the shape and position of the Kuznets Curve to depend on economic freedom indicates that such transitions occur faster and at lower levels of average income in economically free societies. The most precise estimates suggest that rich, economically free democracies such as Australia, Canada, the US and large parts of Northern Europe may already have passed the turning point of the CO₂ Kuznets curve. Focusing on the emission of all greenhouse gases, estimates suggest that further economic development is likely to lead to reduced emissions in most Western societies, as long as their policies are consistently economically free. Estimating the relative use of renewable energy also identifies economically free societies as early adopters. In addition, these estimates slightly underestimate the speed of the transition in economically free societies, as economic freedom also contributes to faster economic growth and productivity increases (Hall and Lawson, 2014; Bjørnskov and Foss, 2016).

Overall, although the theoretical considerations are decidedly mixed, the empirical evidence is not. Environmental Kuznets Curves are typically situated to the left in economically free societies, indicating earlier adoption of clean technology and faster transition towards a low-

respectively). The estimates in Table 4 also indicate a role for the size of government with rich countries with large government sectors moving towards more renewable energy. However, it must be emphasised that the only countries with sufficiently large government sectors and incomes to fit the combination for which this is significant are the three Scandinavian countries. Overall, further tests also show that all main results are robust to for example excluding specific types of autocracies instead of all non-democratic regimes, excluding the very poorest countries, and excluding post-communist countries (cf. Bjørnskov, 2018). The main results are also robust to, for example, controlling for whether countries have ratified the Kyoto Protocol.

emissions society. Conversely, although many of them proclaim a better environment as a central political aim, interventionist governments are likely to achieve the opposite.

References

- Adesina, Kolade Sunday and John W. Muteba Mwamba. 2019. Does economic freedom matter for CO2 emissions? Lessons from Africa. *Journal of Developing Areas*, 53, 155-167.
- Aidt, Toke S., Vitor Castro and Rodrigo Martins. 2018. Shades of red and blue: government ideology and sustainable development. *Public Choice*, 175, 303-323.
- Baker, Scott R., Nicholas Bloom and Steven J. Davis. 2016. Measuring economic policy uncertainty. *Quarterly Journal of Economics*, 131, 1593-1636.
- Barr, Nicolas. 2012. *The Economics of the Welfare State*. Oxford: Oxford University Press.
- Bjørnskov, Christian. 2018. Do liberalizing reforms harm the environment? Evidence from the post-communist transition. *Economic Affairs*, 38, 22-37.
- Bjørnskov, Christian and Nicolai J. Foss. 2016. Institutions, entrepreneurship, and economic growth: What do we know? And what do we still need to know? *Academy of Management Perspectives*, 30, 292-315.
- Bjørnskov, Christian and Martin Rode. 2020. Regime types and regime change: A new dataset on democracy, coups, and political institutions. *Review of International Organizations*, 15, 531-551.
- Blakeley, Grace. 2019. The only way to halt climate change is to challenge the logic of capitalism. *New Statesman*, 5 April.
- Borensztein, Eduardo, José de Gregorio and Jong-Wha Lee. 1998. How does foreign direct investment affect economic growth? *Journal of International Economics*, 45, 115-135.
- Bradley, Steven W. and Peter G. Klein. 2016. Institutions, economic freedom, and entrepreneurship: the contribution of management scholarship. *Academy of Management Perspectives*, 30, 211-221.
- Brambor, Thomas, William Roberts Clark and Matt Golder. 2006. Understanding interaction models: improving empirical analysis. *Political Analysis*, 14, 63-82.
- Buchal, Christoph, Hans-Dieter Karl and Hans-Werner Sinn. 2019. Kohlemotoren, Windmotoren und Dieselmotoren: Was zeigt die CO2-Bilanz? *Ifo Schnelldienst*, 72, 8, 40-54.
- Buchanan, James M. and Gordon Tullock. 1962. *The Calculus of Consent: Logical Foundations of Constitutional Democracy*. Ann Arbor: University of Michigan Press.
- Coates, Dennis, Jac C. Heckelman and Bonnie Wilson. 2010. The political economy of investment: Sclerotic effects from interest groups. *European Journal of Political Economy*, 26, 208-221.

- Dasgupta, Susmita, Benoit Laplante, Hua Wang and David Wheeler. 2002. Confronting the environmental Kuznets curve. *Journal of Economic Perspectives*, 16, 147-168.
- Demena, Binyam Afework and Sylvanus Kwaku Afesorgbor. 2020. The effect of FDI on environmental emissions: Evidence from a meta-analysis. *Energy Policy*. 138, art. 111192.
- Feenstra, Robert C., Robert Inklaar, and Marcel P. Timmer. 2015. The next generation of the Penn World Table. *American Economic Review*, 105, 350–382.
- Greenwood, Dan. 2015. In search of green political economy: steering markets, innovation and the case of the zero carbon homes agenda in England. *Environmental Politics*, 24, 423-441.
- Griliches, Zvi. 1986. Productivity, R&D, and basic research at the firm level in the 1970's. *American Economic Review*, 70, 343-348.
- Grossman, Gene M. and Elhanan Helpman. 2001. *Special Interest Politics*. Cambridge, MA: MIT Press.
- Gwartney, James, Robert Lawson Joshua Hall and Ryan Murphy. 2019. *Economic Freedom of the World. 2019 Annual Report*. Economic Freedom Network, Vancouver BC.
- Hall, Joshua C. and Robert A. Lawson. 2014. Economic freedom of the world: an accounting of the literature. *Contemporary Economic Policy*, 32, 1-19.
- Hayek Friedrich A. 1937. Economics and knowledge. *Economica*, 4, 33–54.
- Hayek, Friedrich A. 1945. The use of knowledge in society. *American Economic Review*, 35, 519–530.
- Hazareesingh, Sudhir. 2015. *How the French Think: An Affectionate Portrait of an Intellectual People*. New York: Basic Books.
- Heckelman, Jac C. and Michael D. Stroup. 2005. A comparison of aggregation methods for measures of economic freedom. *European Journal of Political Economy*, 21, 953–956.
- Heckelman, Jac C. and Bonnie Wilson. 2019. The growth-maximizing level of regulation: Evidence from a panel of international data. *European Journal of Political Economy*, 59, 354-368.
- Hillman, Arye. 1982. Declining industries and political-support protectionist motives. *American Economic Review*, 72, 1180-1187.
- Hodgson, Geoffrey M. 1999. *Economics and Utopia: Why the Learning Economy is Not the End of History*. London: Routledge.
- IPCC. 2014. *AR5 Climate Change 2014: Impacts, Adaptation, and Vulnerability*. New York: Cambridge University Press.
- Jones, Charles I. and John C. Williams. 1998. Measuring the social return to R&D. *Quarterly Journal of Economics*, 113, 1119-1135.
- Keech, William R. and Michael C. Munger. 2015. The anatomy of government failure. *Public Choice*, 164, 1-42.

- Kingston, Christopher. 2007. Parochial corruption. *Journal of Economic Behavior & Organization*, 63, 73–87.
- Kirzner, Israel M. 1973. *Competition and Entrepreneurship*. Chicago: University of Chicago Press.
- Knight, Frank H. 1921. *Risk, Uncertainty, and Profit*. Boston: Houghton and Mifflin.
- Laffont, Jean-Jaques and Jean Tirole. 1991. The politics of government decision-making: a theory of regulatory capture. *Quarterly Journal of Economics*, 106, 1089-1127.
- Laibman, David. 2013. Mature socialism: Design, prerequisites, transitions. *Review of Radical Political Economics*, 45, 501–507.
- Lange, Oscar. 1936. On the economic theory of socialism, part one. *Review of Economic Studies*, 4, 53–71.
- Lange, Oscar. 1937. On the economic theory of socialism, part two. *Review of Economic Studies*, 4, 123–142.
- Lindbeck, Assar and Dennis J. Snower. 2001. Insiders versus outsiders. *Journal of Economic Perspectives*, 15, 165–188.
- Lundström, Susanna and Fredrik Carlsson. 2003. The effects of economic and political freedom on CO₂ emissions. Working paper 29, University of Gothenburg.
- Mazzucato, Mariana. 2013. *The Entrepreneurial State: Debunking Public vs. Private Sector Myths*. London: Anthem Press.
- Mises, Ludwig von. 1920. Die Wirtschaftsrechnung im Sozialistischen Gemeinwesen. *Archiv für Sozialwissenschaft und Sozialpolitik*, 47, 86-121.
- Mises, Ludwig von. 1944. *Bureaucracy*. New Haven: Yale University Press.
- McChesney, Fred S. 1987. Rent extraction and rent creation in the economic theory of regulation. *Journal of Legal Studies*, 16, 101–118.
- Munger, Michael. 2008. Economic choice, political decision, and the problem of limits. *Public Choice*, 137, 507-522.
- Nordhaus, William D. 2007. A review of the *Stern Review on the Economics of Climate Change*. *Journal of Economic Literature*, 65, 686-702.
- Olson, Mancur. 1965. *The Logic of Collective Action: Public Goods and the Theory of Groups*. Cambridge, MA: Harvard University Press.
- Pigou, Arthur Cecil. 1932. *The Economics of Welfare, fourth edition*. London: MacMillan and Co.
- Rafiq, Shuddhasattwa, Ruhul Salim and Ingrid Nielsen. 2016. Urbanization, openness, emissions, and energy intensity: A study of increasingly urbanized emerging economies. *Energy Economics*, 56, 20-28.

- Ricketts, Martin. 1992. Kirzner's theory of entrepreneurship – a critique. In Bruce J. Caldwell and Stephan Boehm (eds.), *Austrian Economics: Tensions and New Directions*. Dordrecht: Springer Verlag, 67-102.
- Rode, Martin D. and Sebastian Coll. 2012. Economic freedom and growth: which policies matter the most? *Constitutional Political Economy*, 23, 95–133.
- Schulman, Jason. 2019. Conceptualizing the future: Marx's value theory and the debate on markets and planning. *Studies in Political Economy*, 100, 1-17.
- Schumpeter, Joseph A. 1943. *Capitalism, Socialism, and Democracy*. London and New York: George Allen & Unwin.
- Shahbaz, Muhammad and Avik Sinha. 2019. Environmental Kuznets curve for CO2 emissions: a literature survey. *Journal of Economic Studies*, 46, 106-168.
- Simon, Julian L. 1981. *The Ultimate Resource*. Princeton: Princeton University Press.
- Sobel, Russell S. and Christopher J. Coyne. 2011. Cointegrating institutions: the time-series properties of country institutional measures. *Journal of Law and Economics*, 54, 111-134.
- Stern, Nicholas. 2007a. *The Economics of Climate Change: The Stern Review*. Cambridge: Cambridge University Press.
- Stern, Nicholas. 2007b. Findings of the Stern Review on the economics of climate change. Chapter 1 in *Yale Symposium on the Stern Review*. New Haven: Yale Center for the Study of Globalization, 7-39.
- Stern, Nicholas. 2008. The economics of climate change. *American Economic Review: Papers and Proceedings*, 98, 1-37.
- Stigler, George J. 1950. The development of utility theory. *Journal of Political Economy*, 58, 307-327.
- Stigler, George J. 1971. The economic theory of regulation. *Bell Journal of Economics*, 2, 3-21.
- Tollison, Robert D. 2012. The economic theory of rent seeking. *Public Choice*, 152, 73-82.
- Treisman, Daniel. 2000. The causes of corruption: A cross-national study. *Journal of Public Economics*, 76, 399–457.
- World Bank. 2019. World Development Indicators. Online database, Washington DC: the World Bank.

Table 1. Descriptive statistics

Variable	Mean	Standard deviation	Observations
CO ₂ emissions per capita (log)	.495	1.729	1216
Log GDP	8.907	1.260	1356
Log population	2.081	1.706	1356
Trade volume	.529	.509	1356
Economic Freedom	6.164	1.314	1098
Size of government	5.893	1.569	1136
Legal quality	5.189	1.896	1061
Policy quality	6.506	1.636	1160
Total greenhouse gases (log)	8.654	1.057	1142
Renewable energy percentage	35.447	21.722	954

Table 2. Simple results

	All countries		Democracies only	
	1	2	3	4
Log GDP	1.748** (.813)	1.877** (.864)	3.839*** (.839)	4.027*** (.845)
Log GDP squared	-.056 (.046)	-.064 (.049)	-.166*** (.044)	-.177*** (.044)
Log population	.411** (.172)	.467** (.183)	.308 (.235)	.308 (.245)
Trade volume	-.018 (.058)	.014 (.054)	.009 (.123)	.043 (.123)
Economic Freedom	.019 (.024)	.027 (.028)	-.001 (.021)	.008 (.025)
Period FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	1006	899	558	507
Countries	155	139	103	95
Within R squared	.390	.389	.433	.439
F statistic	11.51	10.64	8.68	7.71

Note: *** (**) [*] denote significance at $p < .01$ ($p < .05$) [$p < .10$]. Numbers in parentheses are standard errors clustered at the country level. Results in columns 3 and 4 are restricted to countries with full democracy, as captured in the data in Bjørnskov and Rode (2020). In columns 2 and 4, the ten largest oil and gas producers are excluded.

Table 3. Conditional results

	All countries		Democracies only	
	1	2	3	4
Log GDP	-2.099 (1.674)	-2.056 (1.989)	-.838 (1.919)	-.762 (1.953)
Log GDP squared	.175 (.100)	.169 (.122)	.103 (.109)	.096 (.110)
Log population	.455*** (.153)	.514*** (.176)	.318 (.225)	.324 (.236)
Trade volume	.013 (.057)	.034 (.056)	.015 (.121)	.051 (.121)
Economic Freedom	-2.492*** (.890)	-2.620*** (.979)	-2.564* (1.421)	-2.831* (1.469)
GDP * Economic Freedom	.597*** (.213)	.622*** (.239)	.599** (.302)	.653** (.311)
GDP squared *	-.035***	-.036**	-.035**	-.037**
Economic Freedom	(.013)	(.015)	(.016)	(.017)
Period FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	1006	899	558	507
Countries	155	139	103	95
Within R squared	.417	.414	.449	.455
F statistic	13.29	12.20	8.91	7.95

Note: *** (**) [*] denote significance at $p < .01$ ($p < .05$) [$p < .10$]. Numbers in parentheses are standard errors clustered at the country level. Results in columns 3 and 4 are restricted to countries with full democracy, as captured in the data in Bjørnskov and Rode (2020). In columns 2 and 4, the ten largest oil and gas producers are excluded.

Table 4. Total greenhouse gases and renewable energy

	Total greenhouse gases		Renewable energy, percent	
	1	2	3	4
Log GDP	-2.511 (1.715)	-5.517*** (2.111)	6.141*** (1.195)	3.576 (2.675)
Log GDP squared	.176* (.096)	.318*** (.121)	-.411*** (.077)	-.249 (.158)
Log population	.377* (.193)	.248 (.277)	-1.059*** (.239)	-1.271*** (.334)
Trade volume	-.044 (.084)	.003 (.083)	.009 (.079)	-.086 (.224)
Economic Freedom	-1.573* (.926)	-5.804*** (1.532)	3.961*** (.759)	5.815*** (1.571)
GDP * Economic Freedom	.382* (.211)	1.254*** (.343)	-.974*** (.183)	-1.300*** (.345)
GDP squared *	-.023* (.012)	-.068*** (.019)	.059*** (.011)	.073*** (.019)
Economic Freedom				
Period FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	885	434	790	438
Countries	143	88	154	94
Within R squared	.135	.170	.260	.372
F statistic	7.91	5.38	-	-

Note: *** (**) [*] denote significance at $p < .01$ ($p < .05$) [$p < .10$]. Numbers in parentheses are standard errors clustered at the country level. In columns 2 and 4, only democracies are included, as captured in the data in Bjørnskov and Rode (2020), and the ten largest oil and gas producers are excluded.

Table A.1 Included countries

Albania	Czech Republic	Laos	Romania
Algeria	Denmark	Latvia	Russia
Angola	Dominican Republic	Lebanon	Rwanda
Argentina	Ecuador	Lesotho	Saudi Arabia
Armenia	Egypt	Liberia	Senegal
Australia	El Salvador	Lithuania	Serbia
Austria	Estonia	Luxembourg	Seychelles
Azerbaijan	Ethiopia	Macedonia	Sierra Leone
Bahamas	Fiji	Madagascar	Singapore
Bahrain	Finland	Malawi	Slovak Rep
Bangladesh	France	Malaysia	Slovenia
Barbados	Gabon	Mali	South Africa
Belgium	The Gambia	Malta	Spain
Belize	Georgia	Mauritania	Sri Lanka
Benin	Germany	Mauritius	Suriname
Bhutan	Ghana	Mexico	Swaziland
Bolivia	Greece	Moldova	Sweden
Bosnia and Herzegovina	Guatemala	Mongolia	Switzerland
Botswana	Guinea	Montenegro	Syria
Brazil	Guinea-Bissau	Morocco	Taiwan
Brunei Darussalam	Haiti	Mozambique	Tajikistan
Bulgaria	Honduras	Myanmar	Tanzania
Burkina Faso	Hong Kong	Namibia	Thailand
Burundi	Hungary	Nepal	Togo
Cambodia	Iceland	The Netherlands	Trinidad & Tobago
Cameroon	India	New Zealand	Tunisia
Canada	Indonesia	Nicaragua	Turkey
Cape Verde	Iran	Niger	Uganda
Central African Rep.	Ireland	Nigeria	Ukraine
Chad	Israel	Norway	Unit. Arab Emirates.
Chile	Italy	Oman	United Kingdom
China	Jamaica	Pakistan	United States
Colombia	Japan	Panama	Uruguay
Congo, Democratic Rep	Jordan	Paraguay	Venezuela
Congo, Republic of	Kazakhstan	Peru	Vietnam
Costa Rica	Kenya	Philippines	Yemen
Cote d'Ivoire	Korea, South	Poland	Zambia
Croatia	Kuwait	Portugal	Zimbabwe
Cyprus	Kyrgyz Republic	Qatar	

Table A2. Conditional results, components of economic freedom

	Indicator: economic Freedom	Indicator: size of government	Indicator: legal quality	Indicator: policy quality
Log GDP	-.762 (1.953)	6.256*** (1.635)	-.636 (1.442)	-1.325 (1.762)
Log GDP squared	.096 (.110)	-.307*** (.090)	.091 (.077)	.127 (.100)
Log population	.324 (.236)	.275 (.239)	.529*** (.194)	.314 (.239)
Trade volume	.051 (.121)	.043 (.114)	.013 (.081)	.056 (.120)
EFW indicator	-2.831* (1.469)	1.314 (1.031)	-2.570** (1.100)	-3.116*** (1.191)
GDP * EFW indicator	.653** (.311)	-.317 (.228)	.615*** (.235)	.708*** (.256)
GDP squared *	-.037 (.017)	.019 (.012)	-.036*** (.013)	-.039*** (.014)
Period FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	507	506	498	507
Countries	95	95	95	95
Within R squared	.455	.451	.521	.463
F statistic	7.95	7.09	11.52	7.86

Note: *** (**) [*] denote significance at $p < .01$ ($p < .05$) [$p < .10$]. Numbers in parentheses are standard errors clustered at the country level. All results are restricted to countries with full democracy, as captured in the data in Bjørnskov and Rode (2020). In columns 2 and 4, the ten largest oil and gas producers are excluded.

Table A3. Total greenhouse gases, components of economic freedom

	Indicator: economic Freedom	Indicator: size of government	Indicator: legal quality	Indicator: policy quality
Log GDP	-5.517*** (2.111)	.169 (1.660)	-5.089*** (1.615)	-5.629*** (1.871)
Log GDP squared	.318*** (.121)	.001 (.091)	.309*** (.095)	.327*** (.105)
Log population	.248 (.277)	.249 (.273)	.122 (.285)	.164 (.271)
Trade volume	.003 (.083)	-.051 (.083)	-.063 (.096)	.008 (.075)
EFW indicator	-5.804*** (1.532)	-1.194 (1.229)	-4.968*** (1.371)	-5.473*** (1.358)
GDP * EFW indicator	1.254*** (.343)	.243 (.271)	1.121*** (.314)	1.183*** (.295)
GDP squared *	-.068*** (.019)	-.012 (.015)	-.063*** (.018)	-.064*** (.016)
EFW indicator				
Period FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	434	438	420	440
Countries	88	88	88	88
Within R squared	.170	.129	.182	.183
F statistic	5.38	4.78	6.90	6.10

Note: *** (**) [*] denote significance at $p < .01$ ($p < .05$) [$p < .10$]. Numbers in parentheses are standard errors clustered at the country level. In columns 2 and 4, only democracies are included as captured in the data in Bjørnskov and Rode (2020), and the ten largest oil and gas producers are excluded.

Table A4. Renewable energy, components of economic freedom

	1	2	3	4
Log GDP	3.576 (2.675)	-9.093*** (2.502)	1.145 (2.150)	5.265** (2.434)
Log GDP squared	-.249 (.158)	.4799*** (.142)	-.104 (.126)	-.347** (.142)
Log population	-1.271*** (.334)	-1.149*** (.330)	-1.313*** (.337)	-1.249*** (.339)
Trade volume	-.086 (.224)	-.125 (.225)	-.068 (.225)	-.084 (.219)
Economic Freedom	5.815*** (1.571)	-2.534** (1.085)	4.318*** (1.296)	6.279*** (1.312)
GDP * Economic Freedom	-1.300*** (.345)	.618** (.252)	-.983*** (.293)	-1.415*** (.294)
GDP squared *	.073*** (.019)	-.036** (.015)	.055*** (.017)	.080*** (.017)
Economic Freedom				
Period FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	438	437	436	438
Countries	94	94	94	94
Within R squared	.372	.357	.359	.389
F statistic	-	-	-	-

Note: *** (**) [*] denote significance at $p < .01$ ($p < .05$) [$p < .10$]. Numbers in parentheses are standard errors clustered at the country level. In columns 2 and 4, only democracies are included as captured in the data in Bjørnskov and Rode (2020), and the ten largest oil and gas producers are excluded.

Figure 1. Changes in CO₂ emissions, 1990-2015, four EFW categories

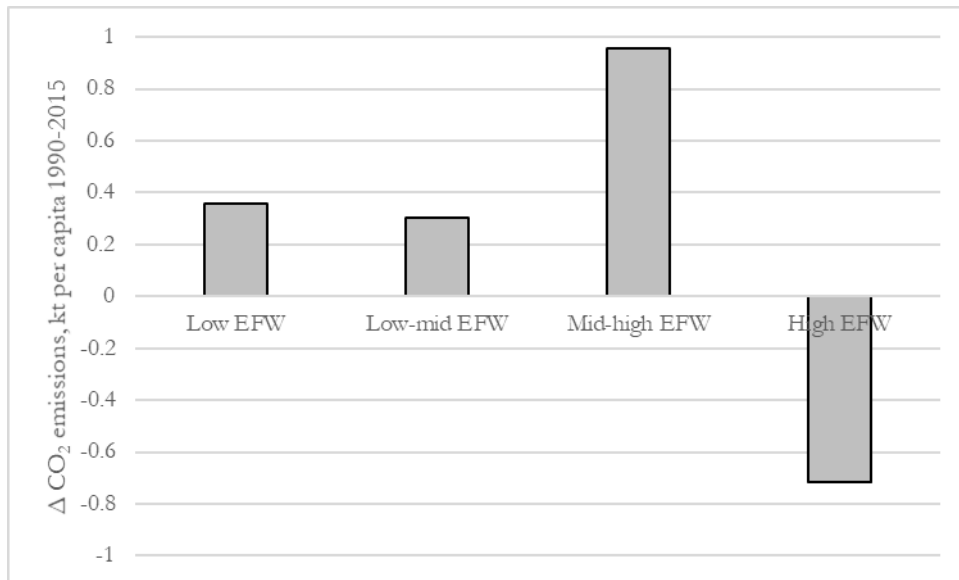


Figure 2. Marginal effects of increasing GDP per capita, high and low EFW scores

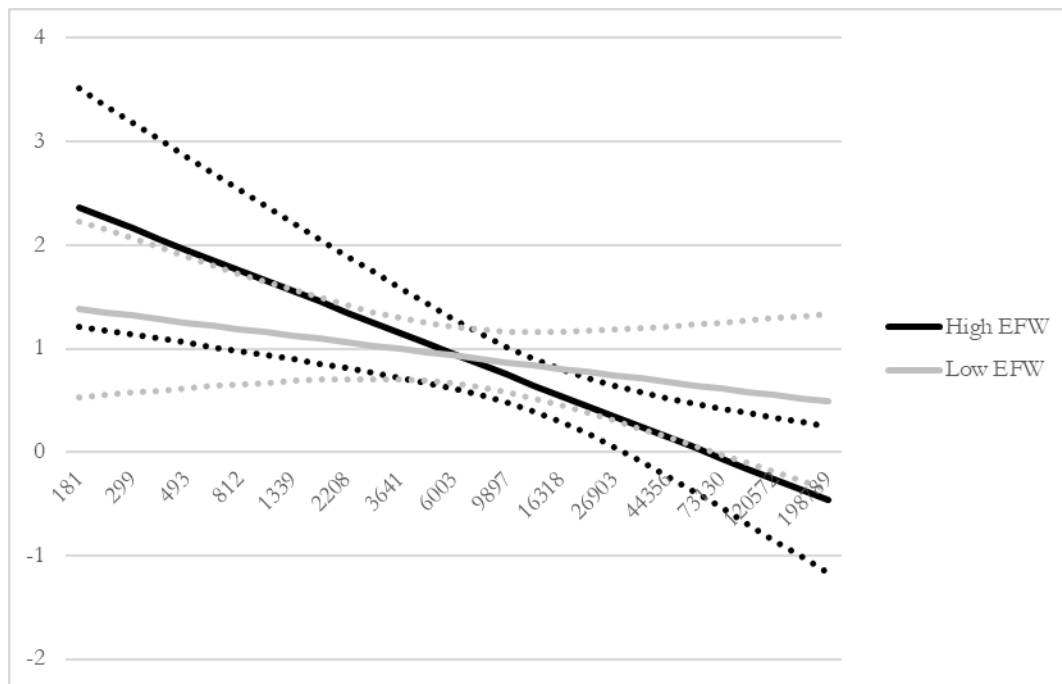


Figure 3. Implied Kuznets Curves

