Varieties of carbon voluntarism in contemporary capitalism

Louison Cahen-Fourot

CEPN
Centre d'économie
de l'Université Paris Nord
CNRS UMR n° 7234

Document de travail du CEPN N° 2016-02

Varieties of carbon voluntarism in contemporary capitalism

Louison CAHEN-FOUROT
Centre d'Économie de Paris-Nord, Université Paris-13 Villetaneuse Sorbonne Paris Cité, 99 avenue Jean-Baptiste Clément 93430 Villetaneuse, France.
Email : louison.cahen-fourot[at]univ-paris13.fr

Document de travail du CEPN n° 2016-02 / CEPN Working Paper n° 2016-02

September 2016

Varieties of carbon voluntarism in contemporary capitalism

Louison CAHEN-FOUROT
Centre d'Économie de Paris-Nord, Université Paris-13 Villetaneuse Sorbonne Paris Cité, 99 avenue Jean-Baptiste Clément 93430 Villetaneuse, France. Email : louison.cahen-fourot[at]univ-paris13.fr

September 2016

Abstract

We investigate national greenhouse gases mitigation objectives, labeled as *carbon voluntarism*, in the context of contemporary globalized finance-led capitalism. Using principal components analysis and clustering, we delineate a typology of OECD and BRICS countries from the standpoint of the assumed underpinnings of carbon voluntarism: the productive structure of the economy, the relative position in global GHG chains, the levels of income and capitalist development, the political demand for the environment, the class structure of GHG emissions and financialization. The least carbon voluntary countries appear to be at the beginning of global GHG chains and to rely heavily on the primary sector. They have a weak political demand for the environment and a more unequal class structure of emissions. The most carbon voluntary countries have a higher political demand for the environment, a more equal class structure of emissions, weaker financialization, and greater reliance on the tertiary sector. These countries are also net importers of GHG emissions.

Key words: capitalism; carbon voluntarism; climate change; COP21; financialization; global GHG chains; greenhouse gases; political demand for the environment

Résumé

On s'intéresse aux objectifs de réduction des émissions de gaz à effet de serre (GES) (le *volontarisme carbone*) dans le contexte du capitalisme globalisé et tiré par la finance. A partir d'une analyse en composante principale et d'une classification, on esquisse une typologie des pays de notre échantillon (OCDE et BRICS) basée sur les déterminants hypothétiques du volontarisme carbone : le tissu productif des économies, la position relative dans les chaines globales de GES, les niveaux de revenu et de développement capitaliste, la demande politique d'environnement, la structure de classe des émissions et le processus de financiarisation. Les pays les moins volontaristes sont ceux situés au début des chaines globales de GES et dont le secteur primaire est le plus important. Ils ont une faible demande politique d'environnement et une structure de classe des émissions plus inégale. Les pays les plus volontaires ont une demande politique d'environnement supérieure, une structure de classe des émissions plus égalitaire, la financiarisation y est moins importante et la tertiarisation plus poussée. Ils sont également importateurs nets de GES.

Mots-clefs : capitalisme ; volontarisme carbone ; changement climatique ; COP21 ; financiarisation ; chaine globale de GES ; gaz à effet de serre ; demande politique d'environnement

1 Introduction

The agreement reached at the COP21 in Paris in December 2015 has been unanimously acclaimed as a historical progress in the struggle against climate change. Yet this agreement merely paves the way for future action, but does not contain in itself any constrained commitment to reduce greenhouse gases (GHG) emissions. In the months preceding the COP21, participating countries submitted their Intended Nationally Determined Contribution (INDCs) through which they exposed their objectives of GHG mitigation by 2030. The future success of the Paris agreement lies in the ability or the willingness of participating countries to commit to their INDC and to improve it for each quinquennial revision scheduled by the agreement. In their current state, the INDCs are insufficient to limit climate change to an increase of 2 degrees Celsius above pre-industrial levels, as explicitly recognized in the agreement itself (United Nations Framework Convention on Climate Change, 2015, p. 3, paragraph 17). It is therefore crucial to understand what determines the stance of countries regarding GHG mitigation, or as we call it in the reminder of this paper, *carbon voluntarism*.

In economics, the literature on international environmental agreements (IEA) pertains mainly to game theory. IEA are analyzed as cooperative and non-cooperative games between countries depicted as rational agents acting individually or collectively to maximize their payoff function of mitigating their emissions or not in the absence of a supranational constraining mechanism (Barrett, 1994; 2005; Tulkens, 1997; 2015; Nordhaus, 2015). The game theory approach to IEA is close to the neorealist school in International Political Economy (IPE) that represents countries as rational individuals taking decisions on the basis of a cost-benefit analysis (Cohen, 2007). From this perspective, States would merely take part in IEA depending on their strategic interest to secure or expand their power (Roberts et al., 2004). If they offer a way to model and interpret the bargaining process itself, these approaches do not explain the underpinnings of these strategic behaviors: Beyond strategic and opportunistic purposes, carbon voluntarism might be the organic product of a combination of economic and socio-political factors historically located. These underpinnings have to be taken into account to comprehend the emergence of new global climate regulations in the historical context of contemporary globalized finance-led capitalism. Building on the institutionalist perspectives of the *Régulation* school (Boyer, 2015) and to a lesser extent of the Diversity of capitalisms (Amable, 2005), our stance is to base the analysis on the underpinnings that we assume to capture some structural features of contemporary capitalism and to have a link with the countries' carbon voluntarism. We focus on the OECD and the

BRICS countries. Another interesting way to follow – perhaps more representative of the diversity of capitalisms methodology - would have been to start from various features of climate policies (carbon taxes, carbon markets, subsidies to renewable energies…) to delineate a diversity of institutional arrangements regarding climate. Such an approach has been adopted in Elie et al. (2012) who investigate the "diversity of environmental institutional devices" and find that they match to some extent with the five capitalisms of Amable (2005). Although they focus on low income countries and include much more variables in their analysis than we do – in particular geographical or demographic variables - our structural approach is more akin to the one followed in Costantini et al. (2016) who investigate structural determinants of alliances between developing countries regarding climate negotiations. We do believe both kinds of approaches are actually relevant and complementary.

The reminder of the paper goes as follows: The second part of the paper explains the theoretical relationships between the assumed underpinnings and carbon voluntarism, the third part details the empirical methodology, the fourth part describes the results and the fifth part discusses them. A conclusion follows.

2 Linking carbon voluntarism to economic and socio-political factors

We conceptualize carbon voluntarism as the product of interactions within countries between socio-political and economic spheres and within global capitalism between countries and/or areas of accumulation that cohabitate in global value chains, which are also chains of GHG emissions. The underpinnings we consider are national economic interests, through the productive structure and the relative position in global GHG chains; national ecological preferences, through the levels of income and capitalist development and the political demand for the environment; and internal class dynamics, through financialization and the class structure of GHG emissions.

2.1 National economic interests: the productive structure of the economy and the relative position in global GHG chains

We assume the countries to adopt a stance in IEA that reflects their national economic interests, the latter shaping to a large extent their carbon volontarism. This is consistent with game theory and IPE neorealism: translated into those approaches, protecting their national economic interest is a way for the countries to maximize their payoff function in the bargaining process. This section thus focuses on the strategic underpinnings of carbon voluntarism.

2.1.1 The productive structure of the economy and tertiarization

The productive structure of the economy refers to the relative importance of the primary, the secondary and the tertiary sectors: The first is mainly composed of agriculture, extractive and energy activities, the second of manufacturing and construction, and the third of services. An effect posited by the Environmental Kuznets Curve (EKC) literature is that progress in economic development and increasing income go together with a shift in the productive structure of the economy towards the tertiary sector. This in turn is assumed to have beneficial effects on environmental degradation, because services require less materials and less waste. However, this effect may be limited in two ways: first, consumption structures still involve material-intensive consumption goods at high income levels and high income economies haven't reduced their material basis despite their tendency towards tertiarization (Martinez-Alier et al., 2010) as the production of services requires high quantities of material inputs (for instance the internet industry needs computers and physical networks to operate). Second, the increase in environmental quality can be partly an illusion because pollution-intensive industries may have simply relocated elsewhere (Van Alstine and Neumayer, 2008). Nevertheless, politically the growth of the tertiary sector can play a useful role towards ambitious climate policies because economic activities, and so the fiscal base of the government, are less directly linked to GHG emissions. Therefore, the governments face less risks of impacting their fiscal base if they implement ambitious climate policies.

2.1.2 The relative position in global GHG chains and GHG offshoring: compossibility at work

The relative position in global GHG chains illustrates that some countries pollute for others. A substantial part of consumption in high-income countries is imported, which induces emissions abroad and thus embodied GHG in international trade (Peters et al., 2012; Peters et al., 2011). This process can be qualified as GHG offshoring for GHG importing countries and as carbon "inshoring" for GHG exporting countries. In illustrating the relative position in global GHG chains, GHG off/in-shoring reflects the extent to which GHG-intensive activities underlie the fiscal base of the government, together with the productive structure of the economy. To account for GHG off/in-shoring, we consider as a proxy whether a country is net importer or net exporter of CO2. The CO2 balance of each country is calculated using consumption and production-based CO_2 emissions. Consumption-based CO_2 emissions are the total emissions induced by the country i final consumption net of domestic emissions induced by final consumption abroad (Peters, 2008):

$$CO2^{i}_{consumption} = CO2^{i}_{production} - CO2^{i}_{embodied\ in\ exports} + CO2^{i}_{embodied\ in\ imports}$$

Production-based emissions are emissions emitted in the country i for a given period. The CO2 balance is therefore simply equal to *consumption-based CO2 – production-based CO2*, which gives us the total amount of CO2 embodied in net imports for one country. Net importers of CO2 are countries whose own final consumption induces more CO2 than they emit domestically; net exporters are countries whose own final consumption induces less CO2 than they emit domestically. Net CO2 importers are the countries at the end of global CO2 chains, those that have offshored their CO2 emissions to the greatest extent. Net CO2 exporters are the countries at the beginning of global CO2 chains, those who kept their emissions inshore.

The figures contained in Table 1 confirm that, for our sample, the most ambitious countries regarding CO2 mitigation objectives tend also to be the countries that are net CO2 importers through embodied CO2 in international trade.

	Average GHG mitigation objectives by 2030 for COP21 in % of 1990 emissions
Net CO2 importers in 2013	6
Net CO2 exporters in 2013	99

Table 1. Average GHG mitigation objectives declared to the United Nations Framework Convention on Climate Change for the COP21. Sources: calculus from the author, UNFCC (INDCs), Climate Action Tracker, Eora I/O Database.

In average, countries that are net CO2 importers in 2013 expect an increase in their GHG emissions of 6 % of their 1990 emissions level by 2030. By comparison, countries that are net CO2 exporters in 2013 expect an average increase in their GHG emissions of 99% of their 1990 emissions level by 2030. Here we must thus go beyond methodological nationalism (Peck and Theodore, 2007) in emphasizing the importance of compossibility in carbon voluntarism: Compossibility is understood in the sense of Jessop (2014, p. 54) as *"the structural coupling, co-evolution and mutual complementarities-exclusivities and their impact on differential accumulation at a world scale"*. Capital accumulation at the world scale by

2030 will likely be based on a global increase of GHG emissions. Their distribution illustrates both mutual complementarities amongst countries within global GHG chains and co-evolution in their GHG emissions: The lowering of carbon emissions in some parts of the world will have as a counterpart an increase in carbon emissions elsewhere. In other terms it means that within global capitalism carbon voluntarism is exclusive: More ecological national accumulation regimes somewhere are possible because less ecological national accumulation regimes remain elsewhere that provide the former with a substantial part of their final consumption. Therefore, high and low ambitions of emissions mitigation cannot be comprehended separately within global capitalism because of the intertwining of national accumulation regimes. As a function of the relative positions in global GHG chains, GHG mitigation objectives are thus a product of compossibility. It should be clear then that even if we regrouped the productive structure of the countries and their relative position in global GHG chains under the label of national economic interests, it also reflects the influence of external factors on a country's carbon voluntarism.

2.2 National ecological preferences: Income, capitalist development and the political demand for environmental policies

Beyond strategic factors such as the national economic interests and their interconnection in global capitalism, the political basis of climate policies are also shaped by the national ecological preferences. We draw on the Environmental Kuznets Curve (EKC) narrative and on the neorealist approach to discuss the socio-political determinants of carbon voluntarism.

2.2.1 Income, capitalist development and the Environmental Kuznets Curve narrative

The impact of income and of development levels on the environment has been classically investigated through the literature on the EKC. Although this relation was never assessed at a macroeconomic level for all kinds of environmental concerns - in particular it was not firmly assessed in the case of CO2 emissions (Stern, 2004), but some recent results provide evidence of an EKC for CO2 (Apergis, 2016) - this does not mean that the levels of income and development do not play a role in the determination of carbon voluntarism. Following the literature on the EKC, we assume they may be related in three main ways.

First, on a microeconomic scale, a usual assumption is that environmental quality is a luxury good. The demand for environmental quality has a positive income elasticity so citizens will get more concerned by ecological matters once they reach a living standard threshold (Berthe and Élie, 2015; Van Alstine and Neumayer, 2008). This assumption entails a notion of subordination of needs and non-substitutability, which makes it impossible to represent in a neoclassical framework within the usual utility function. In terms of the post-Keynesian choice theory it can be understood as lexicographic preferences embodied in a vector of characteristics: Households attempt at satisfying the n_{th} characteristic when the n_{th-1} is already fulfilled (Lavoie, 2014). Lexicographic preferences have been shown to be particularly relevant in understanding environmental choices of individuals (Gowdy and Mayumi, 2001; van den Bergh et al., 2000). In literary terms, the EKC can be dubbed as a *Woody Allen Effect*: When people have solved the materialist question, then they can afford spending a substantial part of their life asking themselves existential questions about life, love and the kind of society they would like to live in, including ecological questions, and trying to shape their life in accordance. From this standpoint, it may explain why Woody Allen's movies often take place in rather bourgeois environments. Such an effect has been investigated in the field of ecological economics in Scruggs (1998). A microeconomic or local EKC might then occur if people can afford to adapt their life to their belief according to a set of lexicographic preferences encompassing ecological issues. Empirical results have suggested the occurrence of an EKC for some local pollutants (Dinda, 2004).

However, the social determinism of the EKC is problematic: It is clearly not because one becomes wealthier that one will naturally become more virtuous from an ecological standpoint. Regarding GHG, empirical evidences show that wealthier people are also those that have the largest emissions, even though some results also show that the GHG intensity of consumption is negatively correlated with the level of income (Berthe and Élie, 2015; Lenglart et al., 2010; Chancel and Piketty, 2015). This could indicate that, for a given living standard, wealthier households may try to reduce their ecological impact in consuming more ecological products, which is consistent with the lexicographic nature of environmental preferences.

Another limit to the EKC is that, once understood as a mechanical relation between income and ecological virtue, it cannot account for situations where the surrounding natural environment is directly at stake for survival, an important matter in the environmentalism of the poor and environmental justice movements (Martinez-Alier, 2014). In this case, the trade-off between income and ecology may not be possible and the above lexicographic ordering may be questionable, or may even be reversed: The preservation of nature may come first, and an increase in income may be aimed for if, and only if, preservation of nature is achieved.

When taken at the household level, the level of income may thus be considered a factor of the political demand for environmental quality, although it cannot obviously be considered to be the sole factor.

Secondly, the income and development factor may play a role both at the firm and the macroeconomic levels, through the spreading of innovations increasing productivity and allowing for improvements in the use of resources and production of waste. The long-term relationship linking GDP growth and technology is a well-known theoretical and empirical fact known as the Kaldor-Verdoorn's Law: As aggregate demand increases so do incentives to innovate (Kaldor, 1975; Knell, 2004; Angeriz et al., 2009; Millemaci and Ofria, 2014). Even though the environmental effect of technology is ambiguous because of potential Jevons effects – that is the increase in consumption by the means of energy savings (Van Alstine and Neumayer, 2008), capitalist development may then be considered a proxy for the technological ability to reduce GHG emissions and therefore a determinant of carbon voluntarism.

Finally, at the macro level, economy-wide public policies might be of greater importance for determining the income/development-environment nexus than the sum of individual will and actions from households and firms. From this perspective, we expect wealthier countries to have more abilities in implementing environmental policies than poorer ones because they simply have more technological and financial wherewithal for doing so. Indeed, some INDCs of low and middle-income countries explicitly integrate financial transfers in order to implement emissions reduction policies or to raise their GHG mitigation objectives (see Mexico or Gabon for instance) and a crucial issue at the COP21 was financial commitments from high income countries towards middle and low income countries.

To sum up, we assume income and capitalist development to be important determinants for carbon voluntarism because of a Woody Allen effect on households' preferences, because of the broadening of technological possibilities and because of an increase in financial means to implement public policies aimed at emissions mitigation.

2.2.2 The political demand for the environment as the social basis of environmental policies

Environmental issues and benefits might not be evenly distributed socially and geographically, so they might not affect social classes in the same way or similar intensity. Therefore different classes may have conflicting interests regarding environmental regulations. As the neorealist[1] approach shows, social expectations are the product of conflicting ideologies translated into political demands (Amable and Palombarini, 2008; Guillaud and Palombarini, 2006). Therefore, with the degradation of the environmental conditions of production, one may analyse the emergence of environmentalism as a mean to shift the political mediation between conflicting interests towards new institutions, i.e., more severe environmental regulations. Climate policy may thus be seen as part of a compromise between antagonistic classes. It embodies in new institutions, here environmental regulations such as emissions mitigation, to ensure the adequate reproduction of the environmental conditions of production. As Elie et al. (2012) show, environmental regulations vary across models of capitalism and do not emerge in a historical vacuum: They illustrate this process of institutionalisation of environmentalism. O'Connor (2008) points out the role of environmentalism in the process leading to new institutional compromises to regulate capitalism (p. 27):

> "*As labor exploitation (...) engendered a labor movement which during particular times and places turned itself into a "social barrier" to capital, nature exploitation (...) engenders an environmental movement (...) which may also constitute a "social barrier" to capital.*"

In the Neorealist framework, environmental policies are new institutions emerging as a compromise between antagonistic classes forming a dominant social bloc on ecological issues. As part of the socio-political basis of such policies, the political demand for the environment might be a key determinant of carbon voluntarism. It also captures the influence of non-governmental organizations acting at the supranational level, although we encompass the political demand for the environment into the national ecological preferences categories. The more these organizations are supported in every country, the more influential they can be both nationally and internationally.

2.3 Class dynamics: financialization and the class structure of emissions

Financialization refers to the transformations in the nature of capital accumulation since the end of the Fordist regime of accumulation (Boyer, 2000). Drawing on the literature, we define financialization as the process of the emergence of finance as a major sector of the economy

[1] The neorealist approach of Amable and Palombarini is not to be confused with the neorealist approach in International Political Economy mentioned in the introduction. Both terms "neorealist" refer to different fields.

and as the governing principle of nonfinancial corporations' management (Epstein, 2005; Krippner, 2005; van der Zwan, 2014). This is a synthetic definition that has no pretention to be exhaustive. Financialization is considered as a major factor of the shift in the relations between labour and capital that has occurred in the past 40 years (Duménil and Lévy, 2012). In this work, we will mostly focus on the second part of the definition that is the financialization of firm management, even though the rise of finance as a sector is taken into account through the productive structure of the economy. To distinguish from sectorial financialization, we refer to the financialization of firm management as financial accumulation on the one hand – because it has led to the primacy of financial capital over productive capital – and functional financialization on the other hand – because it has shifted the functional income distribution between labour and capital. The shift in class dynamics entailed by the financialization process produces particular configurations of the class structure of GHG emissions that can have political consequences for climate policies.

2.3.1 The financial turn of accumulation: The crowding-out of productive investment and innovation

Financial accumulation refers to the decrease in productive investment and to the increase in financial investment, stock buybacks and distributed profits through dividends and interest. At the macroeconomic level, several authors established a negative relationship between financialization, investment and capital accumulation in high income countries (Stockhammer, 2004, 2006, 2010; Cordonnier, 2006; Husson, 2010). At the firm level, the literature also show compelling evidences of a shift from the "retain and reinvest" model to the "downsize and distribute" model of firm management leading to a crowding-out of productive investment and innovation (Lazonick and O'Sullivan, 2000; Orhangazi, 2008; Clévenot et al., 2010; Lazonick, 2010; Seo et al., 2012).

The trade-off between financial requirements and capital accumulation illustrate a reluctance towards long-term investment and innovation that might prove a brake towards an ambitious climate policy on four grounds: firstly, in limiting countries' ability to renew their productive structure, i.e. to shift towards less polluting and more efficient production processes because of a lack of investment and innovation; secondly, because offshoring may occur to increase financial profitability; thirdly, because faced with financialization, governments may therefore limit their emissions reduction ambitions to safeguard their fiscal base; and last but not least, because less productive investment means less activity and so less wages. Aggregate demand is then decreased, weakening the Kaldor-Verdoorn relationship between growth and innovation and therefore the ability to improve production processes towards less GHG emissions as economic development occurs.

2.3.2 The decreasing labour share and the class structure of emissions

Alongside capital accumulation, the labour share in income distribution has also declined as a result of financialization, resulting in a shift in the wage-labour nexus (Boyer, 2000). A number of studies using diverse measures of financialization found an inverse relationship with the labour share for an extensive number of countries (Jayadev, 2007; Jayadev and Epstein, 2007; Dünhaupt, 2011, 2012, 2013a, 2013b; Stockhammer, 2012; Husson, 2010; Köhler et al., 2015).

The increasing pressure over the labour share might be a brake towards ambitious climate policies. In case of tighter GHG mitigation regulations, firms might have to invest in productive capital and innovation to decrease their emissions. However, faced with financial pressures, firms can hardly decrease the share of income dedicated to meeting current standards on returns on investment. In other words, for a given profit, in finance-led capitalism firms cannot decrease the profit share that goes to financial capital. In order to invest to comply with environmental regulations, firms might then decrease employment or wages and so the labour share. Functional financialization might then shape carbon voluntarism through four channels: First, governments might be reluctant to pursue ambitious climate policies to avoid increasing the pressure on the labour share and so on their fiscal base if firms were to devote an increased share of income to emissions mitigation. Second, a decreasing labour share may have negative impacts if understood in terms of the EKC, because it will prevent households from reaching the threshold at which they will express or implement ecological preferences. Third, in terms of the Kaldor-Verdoorn relationship, a decreasing labour share might be a factor of lower economic activity and so of incentive to innovate. Fourthly, as a factor of widening inequalities between workers and capital owners and between the top management and other categories of workers (Dünhaupt, 2011), the decreasing labour share also affects the class structure of GHG emissions. As said earlier, the wealthiest people are the most emitting. In case of a highly unequal class structure of emissions, carbon voluntarism might be faced with two political complementary mechanisms: The dominant class will defend its GHG-intensive lifestyle while the dominated class might refuse to mitigate its emissions since they are lower, considering that desires and preferences often polarize around the dominant way of life (Wisman, 2011; Veblen, 1979). Therefore, a highly unequal class structure of emissions might prevent the formation of a dominant social bloc supporting climate policies because the dominant way of life may be seen as a power to achieve, *"which is durably inscribed in the bodies of the dominated, in the form of schemes of perception and dispositions (to respect, admire, love, etc.), in other words, beliefs which make one sensitive to certain public manifestations, such as public representations of power"* (Bourdieu, 2000, p. 171).

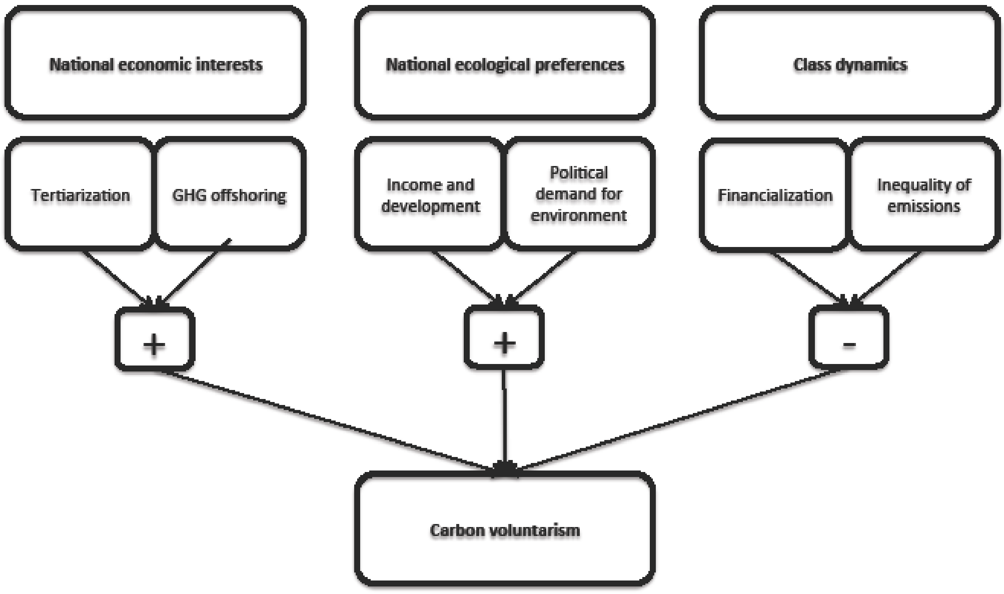

Figure 1. The underpinnings of carbon voluntarism and their effects.

Figure 1 summarizes the theoretical links between its assumed underpinnings and carbon voluntarism. Drawing on carbon voluntarism understood as the product of all these factors and their interactions, we attempt at delineating a typology of countries from this perspective. The next part will present our sample of countries and the data used to proceed to our statistical analysis.

3 Empirical methodology

This section presents in turn the sample and data used and the statistical methods. We used two exploratory statistical techniques. First, we applied a principal components analysis (PCA) to our economic and socio-political variables. Second we proceeded to a mixed hierarchical and K-mean clustering to obtain a typology of the countries that we compared with their carbon voluntarism.

3.1 Sample and data

Our sample is made of 37 OECD and BRICS countries.[2] These countries account for about 80% of world GDP, 60% of the world population and 70% of global GHG emissions and are therefore the main stakeholders in climate negotiations. Fourteen variables are included, thirteen of which are used for the statistical analysis. Table 2 presents the data, their meaning and their sources[3].

Underpinnings	Variable	Meaning	Source
Carbon voluntarism	**COP21**	GHG reduction objective for COP21	INDCs; Climate Action Tracker; emissions data from UNFCC, Edgar v4.2 FT2012 and Eurostat; calculations from the author
Productive structure	**PrimAgri**	Primary sector, agriculture: share in gross value added (NACE: A)	OECDStat; World Development Indicators
	PrimIndus	Primary sector, extractive and energy activities: share in gross value added (NACE: B to E except C)	
	SecManuf	Secondary sector, manufacturing: share in gross value added (NACE: C)	
	SecConst	Secondary sector, construction: share in gross value added (NACE: F)	
	Ter_Serv	Tertiary sector, non-FIRE activities: share in gross value added (NACE: G to U except K and L)	
	Ter_FIRE	Tertiary sector, financial, insurance and real estate activities: share in gross value added (NACE: K and L)	
Income and development	**GDPCap**	2015 GDP per capita in 2014 US$	Total Economy Database
Relative position in global GHG chains	**EmbCO2**	2013 share of net embodied CO2 in imports (exports)	Eora Input-Ouput Database v. 199.82 (Lenzen et al., 2013)
Political demand for the environment	**IUCN**	Number of org. belonging to the International Union for the Conservation of Nature per millions of people and financial supporters of Greenpeace in % of population	IUCN, World Development Indicators (population)
	GreenP		Greenpeace national websites and annual reports and World Development Indicators (population)
Class structure of emissions	**ClassGHG**	Inter-decile ratio of emissions	Chancel and Piketty (2015), OECDStat
Financialization	**FinIndex**	Share of not-reinvested profit in % of GDP.	OECDStat and Ameco
	WShare	Wage share at factor cost	

Table 2. Variables and sources.

We measure carbon voluntarism as the mitigation objectives declared for the COP21: We assume the COP21 contribution of a country to be a synthetic indicator of its carbon voluntarism. For countries with a base year other than 1990 or basing their mitigation objective relatively to a business-as-usual scenario, 1990 equivalencies were either taken from

[2]. Australia, Austria, Belgium, Brazil, Canada, Chile, China, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, India, Ireland, Israel, Italy, Japan, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Russia, Slovakia, Slovenia, South Africa, South Korea, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

[3] For a matter of space, the values are given in the supplementary material.

the *Climate Action Tracker* website[4] (CAT) or computed by the author using the following formulae:

$$\frac{[\left(E^{i}_{base\,year} - \varphi^{i}_{E_{base\,year}} \times E^{i}_{base\,year}\right) - E^{i}_{1990}]}{E^{i}_{1990}} \times 100$$

With E^{i}_{1990} emissions of country i in 1990, $E^{i}_{base\,year}$ the emissions of country i in the base year and $\varphi^{i}_{E_{base\,year}}$ country's i percentage of base year emissions mitigation as declared for the COP21. Equivalencies in absolute emissions when INDCs were declared in GHG intensity of GDP were taken from CAT or calculated by the author. Equivalencies in emissions excluding *Land Use, Land Use Change and Forestry* (LULUCF) when INDCs were declared including LULUCF were taken from *Climate Action Tracker*. The reason to exclude LULUCF is that it allows for concentrating on emissions from industrial sources and energy combustion, avoiding the bias introduced by CO2 capture of forests and plants, which may act as an offsetting mechanism. Therefore, it better reflects real mitigation. Some particular cases should be noted. First, the European Union submitted a collective INDC with an overall objective of a 40% decrease in emissions by 2030 compared to 1990. The European Commission later released national emissions target for each EU member for the sectors not included in the EU Emissions Trading System (EUETS): agriculture, construction, waste management, transportation, CO2 capture and storage as well as LULUCF. At the EU level, these sectors are to reduce their total emissions by 30% relative to 2005 (European Commission, 2016)[5]. The EU ETS scheme includes

> "*heavy energy-using installations consisting of power stations and other combustion plants with ≥ 20MW thermal rated input (except hazardous or municipal waste installations), oil refineries, coke ovens, iron and steel, cement clinker, glass, lime, bricks, ceramics, pulp, paper and board, aluminium, petrochemicals, ammonia, nitric, adipic and glyoxylic acid production, CO2 capture, transport in pipelines and geological storage of CO2. The aviation scope of the EU ETS is limited to flights within the EEA until 2016 (...).*" (European Commission, n.d., p. 20)

The EU mitigation objective for the ETS sectors is 43% by 2030 compared to 2005. We computed a value for the COP21 variable combining both the national objectives for the non-ETS sectors and the EU objective for the ETS sectors[6]. The individual objectives regarding

---

[4] http://climateactiontracker.org/, accessed August 3, 2016.

[5] The national emissions targets are propositions and will be subject to negotiations. Moreover, they include the United Kingdom and are also subject to change because of the Brexit.

[6] See the supplementary material for the detailed calculation.

non-ETS sectors include LULUCF and no equivalency excluding LULUCF was available. However, the differentiation with the EU target for major industrial and energy sectors covered by the ETS decreases the impact of including LULUCF. Second, for the USA, the INDC stated an objective of 28% mitigation including LULUCF by 2025 compared to 2005, while the other INDCs stated objective by 2030. We took the equivalency excluding LULUCF provided by CAT and computed the average annual mitigation rate from 2005 to 2025. We assumed this rate would hold for the period 2025-2030 and computed the expected level of emissions excluding LULUCF in 2030. We then computed the equivalency in terms of 1990 emissions. Third, for New Zealand, Norway and Switzerland, the value for *COP21* includes LULUCF because no equivalency excluding LULUCF was available. Ways of accounting for LULUCF may also differ. Fourthly, a few countries such as New Zealand and Switzerland aim at including offsetting of emissions abroad through tools such as the *Clean Development Mechanism* that allows to earn emissions credits by reducing or avoiding emissions in developing countries. In itself, the inclusion of such a mechanism in the INDC indicates a will to reduce the impact of climate policies on the domestic economy and thus of a lower carbon voluntarism than the value of *COP21* may suggest. Therefore, the *COP21* variable is not perfectly homogenous amongst the countries because of accounting differences. If this is clearly a difficulty for comparability to bear in mind, it should however be noted that for all countries the non-LULUCF sectors and the domestic measures to be implemented play the major role and that for the countries in which LULUCF is more likely to play an important role, such as Brazil and Russia, equivalencies excluding LULUCF were available. For these reasons, we will nonetheless proceed to comparisons amongst countries or group of countries. For the various calculations regarding the levels of carbon voluntarism we took emissions data from the UNFCC whenever possible, from the Edgar database otherwise: Comparisons of common available years from the two sources shown data consistency. The *COP21* variable is not part of the PCA and the clustering: We performed the analysis upon the underpinnings assumed to produce carbon voluntarism. Then we compared the typology obtained to carbon voluntarism to see if it matches our theoretical reasoning.

The productive structure is captured through the respective shares of the primary, the secondary and the tertiary sectors, each of them being split in two activities or group of activities to refine the analysis. 2015 values were taken except for Australia, Ireland, Israel, Russia, South Africa, South Korea, Switzerland, Turkey, United States (2014), China (2013), New Zealand (2012), Brazil (2011) and India (2009). For South Africa and Russia, ISIC revision 3 data were taken because of missing data in revision 4. For these countries, the FIRE sector may therefore be overestimated because it is merged with other activities. For China, OECD and World Bank data were combined to isolate manufacturing. Income and capitalist development are represented by the GDP per capita for 2015. The relative position in global GHG chains is approximated by the 2013 share of CO2 emissions embodied in imports net of embodied CO2 emissions in exports over the period. The political demand for the environment is proxied through two variables: The number of governmental and nongovernmental organizations members of the IUCN per millions of people up to date as of August 2015 and the number of financial supporters of Greenpeace as a percentage of the population for the most recent year available. Three countries, Estonia, Ireland and Portugal have no local Greenpeace organization and have therefore a value of 0 for the variable. While it may induce a bias in the analysis, the absence of such an important environmental NGO may also mean something regarding the local political demand for environment. The class structure of emissions is estimated through the ratio of the emissions of the 9th decile of income distribution to the emissions of the 1st decile of income distribution for 2013, except for Australia (2003), New Zealand (1998) and Switzerland (D9/D2 ratio). Data were missing for Chile: the value for the D9/D1 income ratio from OECDStat was chosen as a proxy, since the D9/D1 emissions ratio and the D9/D1 income ratio appeared very close for the whole sample. Finally, financialization is composed of two variables: *FinIndex* proxies financial accumulation as the difference between the gross margin rate and the gross fixed capital formation rate, or, in other terms, the share of profit in GDP that is not reinvested. 2014 values were taken except for Australia, Chile, Japan, Mexico, New Zealand, Poland, Russia, South Africa, South Korea, Switzerland, United States (2013), China, Israel (2012), India (2009) and Turkey (2006). Functional financialization is proxied by the adjusted wage share at factor cost from Ameco. For BRICS countries and Israel, data were taken from OECDStat and the wage share was computed as $\frac{W}{Y-T} \times 100$ with W the compensation of employees, Y the GDP and T the taxes and subsidies on production and imports, so to have the wage share at factor cost. 2015 values were taken except for Australia, New Zealand (2014), Chile, Russia, South Korea, South Africa (2013), China, Israel, Mexico, (2012), India (2009) and Turkey (2006). Here one should note that a higher wage share means a lower functional financialization.

3.2 *Principal Components Analysis*

PCA is an exploratory statistical method that allows for synthesising a set of multiple variables into a limited number of orthogonal components: the factor axes. Each component synthesizes a decreasing but supplementary fraction of the total variance (inertia) in the variables. The first axis synthesizes the biggest part of the inertia, the second axis synthesizes an additional but smaller part of the inertia and so on: The axes are additive to one another because they are completely uncorrelated (Roux, 2014; Vyas and Kumaranayake, 2006). To choose the number of axes to keep we followed the Keiser criterion: We kept the axes with an eigenvalue greater than the average. Since we performed a normalized PCA, the sum of eigenvalues is equal to the number of the active variables and so the average eigenvalue is 1. Axes 1 to 5 fulfil the Keiser criterion[7]. Proceeding first to a PCA produces a more robust clustering with more stable clusters since the noise has been taken out through the removal of the residual axes (Husson et al., 2010).

3.3 *Clustering*

We then proceeded to a mixed method of hierarchical and partitioning clustering upon the five synthetic variables kept in the PCA. The hierarchical ascendant clustering determined the number of classes to keep according to the factor axes so to avoid choosing a number of classes *ex ante* and arbitrarily. To choose the number of classes to keep, we relied on several criteria: the optimal number of clusters suggested by the algorithm[8]; the inertia gain of partitioning to another cluster; the length of the links on the diagram and the extent to which each class is interpretable (Husson et al., 2010). Given these criteria, we kept four clusters. Consolidating the clusters using K-means partitioning reduces the inertia inside each cluster, giving more homogeneous clusters and improving the partition. Table 3 shows the results of the clustering[9].

---

[7] The detailed results for the PCA are given in the supplementary material.

[8] The statistical analysis was performed using the FactoMineR package of R.

[9] As explained, the clustering was performed of the synthetic axes obtained from the PCA and not on the raw variables. However, it is more relevant to come back to the variables for the analysis. The results for the clusters in terms of the axes are presented in the supplementary material.

Cluster	Countries	Variables	COP21 (%)	PrimAgri (%)	PrimIndus (%)	SecManuf (%)	SecConst (%)	Ter_Serv (%)	Ter_FIRE (%)	GDPCap	EmbCO2 (%)	IUCN	GreenP (%)	FinIndex (%)	WShare (%)	ClassGHG
1	Brazil, Chile, China, *India*, **Mexico**, Poland, Slovakia, Turkey	**Mean**	171	**6,79**	6,94	17,96	**7,10**	**46,13**	**12,38**	**18 568**	7,52	**0,12**	0,06	27,70	**45**	**7,74**
		St. dev.	175	4,67	3,08	5,33	0,95	7,04	3,64	6 955	17,90	0,07	0,05	15,69	8,31	3,40
2	Australia, **Canada**, *Norway*, Russia, South Africa	**Mean**	-6	2,46	**14,12**	**10,86**	6,48	48,40	18,40	40 328	-0,33	0,60	0,22	16,47	59	6,27
		St. dev.	20	0,97	5,68	3,28	1,55	3,61	3,50	18 878	21,27	0,40	0,22	4,77	4,52	2,56
3	Austria, Czech Rep., Estonia, Germany, *Greece*, Hungary, Ireland, Israel, Italy, **Japan**, Portugal, Slovenia, South Korea, Spain, UK, US	**Mean**	-15	2,10	**3,61**	17,61	**4,93**	55,06	16,25	36 712	16,83	0,54	0,19	23,05	60	4,75
		St. dev.	46	1,03	0,96	5,63	1,03	3,88	3,23	8 610	13,42	0,33	0,31	7,21	6,09	1,72
4	Belgium, **Denmark**, Finland, France, Netherlands, New Zealand, Sweden, *Switzerland*	**Mean**	-40	2,08	3,56	14,04	5,38	**59,25**	15,38	**45 684**	**27,00**	**1,58**	**1,05**	15,84	**65**	3,84
		St. dev.	13	1,64	1,12	2,56	0,58	4,41	2,91	6 225	20,16	0,53	0,70	4,23	4,05	0,85
Overall mean			**21**	**3,16**	**5,74**	**16,00**	**5,71**	**53,14**	**15,51**	**35 218**	**14,70**	**0,68**	**0,35**	**21,61**	**57,70**	**5,41**
Overall standard dev.			**118**	**3,09**	**4,46**	**5,39**	**1,36**	**6,82**	**3,79**	**13 681**	**19,30**	**0,62**	**0,54**	**10,12**	**9,10**	**2,61**

Table 3. The classes obtained from the clustering, the average values and standard deviations of the variables for each category and the overall sample, and the average carbon voluntarisms for each class. Values for characterizing variables of each class are in bold. Parangons are in bold and most distinct countries in italic.

For each cluster, the parangon (the closest country to the barycentre of a cluster) is in bold and the most distinct country (the furthest country from the barycentre of the other clusters) is in italic. The significant variables to characterize a cluster have their values in bold for the corresponding cluster. The significance is given by the test-values reported in the appendix.

4 Results

A first thought is that all the clusters are rather heterogeneous in terms of carbon voluntarism, as shown by the standard deviations of *COP21*. Indeed, ultimately each country has its own stance towards carbon voluntarism so clustering involves necessarily some arbitrariness and nuances. The clusters include at least one country that appears at odds with their average carbon voluntarism: Poland and Slovakia in cluster 1, Norway in cluster 2, Israel, Portugal, South Korea and Spain in cluster 3 and New Zealand in cluster 4. However, this does not mean that our typology is inconsistent: Our results exhibit a clear trend from very low to average carbon voluntarism[10] rather in line with our theoretical premises.

Cluster 1 is composed of emerging countries as well as Poland and Slovakia and has the lowest average carbon voluntarism. The primary sector is at the core of the countries' national economic interests as shown by the share of agriculture in the gross value added, the highest of all the clusters, and the share of the extractive and energy activities, the second highest. This cluster has also the highest share of manufacturing and the lowest share of the tertiary sector. The average productive structure of this cluster as well as the low share of net embodied CO2 in imports indicates that these countries tend to be at the beginning of global GHG chains. The cluster is also characterized by the weakest ecological preferences as shown by the values of *IUCN* and *GreenP*. Strong internal class dynamics are at work: it has the highest *FinIndex* value and the lowest wage share and the class structure of emissions is the most unequal. Cluster 2 encompasses both emerging and high income countries strongly relying on the primary sector, in particular extractive and energy activities and is the second lowest is terms of carbon voluntarism. Similarly to cluster 1, these countries can therefore be considered at the beginning of global GHG chains, as exemplified by the cluster's negative share of net embodied CO2, which means that in average the countries of cluster 2 are net exporters of GHG. Their class structure of emissions is the second most unequal after cluster 1. Cluster 3 is composed for more than half of Southern, Central and Eastern European

---

[10] See table 5 and supplementary material for details on the ranking of carbon voluntarisms from *very low* to *high*.

countries, and has a *low* carbon voluntarism depending on the assumption regarding EU members' individual objectives. These countries are characterized by a strong secondary sector, especially manufacturing activities, as opposed to their primary sector, while they also appear strongly relying on their tertiary sector. Cluster 3 has an average level of political demand for the environment similar to cluster 2. Its class structure of emissions is however more equal. Cluster 4 is made of central and Northern European countries as well as New Zealand. These countries have a prominent tertiary sector. They are at the end of global GHG chains as shown by their high share of net embodied CO2 in imports. In average, they also have the lowest *FinIndex* values and the highest wage share. Cluster 4 also exhibits the most equal class structure of emissions and is characterized by the strongest political demand for the environment.

5 Discussion

Based on our results, table 5 synthezises the varieties of carbon voluntarism from *very low* to *average* according to a benchmark based upon the last report of the Intergovernmental Panel on Climate Change (IPCC, 2014).

Cluster	**IPCC benchmark mitigation clusters average (%)**	**COP21 (%)**	**Varieties of carbon voluntarism**	
			Ranking	**Summary**
1	3	171	Very Low	Emerging countries with prominent primary and secondary sectors, a lower political demand for the environment, a higher financialization and an unequal class structure of emissions
2	-42	-6	Low	High income and emerging countries net exporters of GHG with important extractive and energy activities, and an unequal class structure of emissions.
3	-51	-15		High income countries with strong secondary and tertiary sectors.
4	-55	-40	High	High income countries with a prominent tertiary sector, a higher share of imported GHG, a lower financialization, a more equal class structure of emissions and a higher political demand for the environment.

Table 5. IPCC scenario RCP 2.6 (66-100% chance to limit climate change to 2 degrees Celsius) was used as a benchmark (IPCC, 2014). Carbon voluntarisms are ranked from *very low* to *high* according to the following rules: *very low* means an increase in GHG emissions by 2030; *low* means a mitigation of less than half the benchmark rate; *average* means a mitigation from half to two thirds of the benchmark rate; *high*

means a mitigation from two thirds of the benchmark rate onwards. See appendix 6 in the supplementary material for computation details.

A general thought arising from these results is that explaining carbon voluntarism entirely by the levels of income and development of a country is insufficient. Even though income, capitalist development and the productive structure are linked to each other, we can see that the latter may have an impact on its own with cluster 2, which is composed of high income and emerging countries that rely strongly on the primary sector and that are not so carbon voluntary despite an average value of *GDPCap* higher than for cluster 3. As we assumed theoretically, countries adopt a stance towards GHG mitigation that is consistent with their fiscal base. Indeed, carbon voluntarism follows national economic interests: the more the countries rely on the primary sector, the less they are carbon voluntary. This result may help shedding light on the uncertainty about an EKC for global pollutants: income and capitalist development do not determine alone a linear path towards more environmental policies. The underlying structure of the economy is to be taken into account to understand this path. This should also cause us to look for a more nuanced view than the usual representation of climate policies as developed versus developing countries issues. That representation is not false as our results show, but it oversimplifies the possible explanations of a country carbon voluntarism: Both developed and developing countries are neither homogenous amongst each other nor are they a homogenous body deprived of its own internal dynamics. We do not say that the levels of income and capitalist development play no role: As we can see, there is a clear tendency of richer nations to be more carbon voluntary. However, this last observation is tamed by the relative position of countries in global GHG chains. Except for the high income countries of cluster 2, the richest countries are at the end of these chains, with the highest share of net embodied GHG in their imports, or, in other terms, with the highest GHG offshoring, as shown by the values of *EmbCO2*. This result shows that compossibility within global capitalism plays an important role in the determination of carbon voluntarism: End-of-pipe countries in global GHG chains rely on emerging countries for a substantial part of the emissions induced by their own consumption. At the global level, a core determinant of carbon voluntarism then appears to be the international division of labour, which closely overlaps with the international division of GHG emissions.

Although the effect of the levels of income and development is to be nuanced, national ecological preferences appear to be an important factor. The higher the political demand for the environment, the higher carbon voluntarism as shown by the values of *IUCN* and *GreenP* for clusters 1 that has the lowest political demand for the environment, and 4 that has the highest level. However, cluster 1 low political demand for the environment might also show that the kind of environmentalism that dominates in emerging countries is closer to the environmentalism of the poor or environmental justice movements (Martinez-Alier, 2002; 2014) than to the environmentalism reflected by our variables, more akin to institutional environmentalism. The pregnancy of a strong political demand for the environment in the most carbon voluntary countries may also reflect the existence of a dominant bloc supporting institutional arrangements for a higher GHG mitigation. This explanation is consistent with what the analysis shows for the internal class dynamics. There is a tendency for a lower level of financialization, both for financial accumulation and functional financialization, to be associated with a higher carbon voluntarism. In line with our theoretical reasoning, it may be that the weaker the financialization process, the less the governments are reluctant to adopt climate policies because they fear less for their fiscal base to be negatively impacted and for the labour share to be put under more pressure. Moreover, a more equal class structure of GHG emissions goes with a higher carbon voluntarism: In the most equal countries in terms of GHG emissions, it may be easier to reach institutional compromise in favor of climate policies because GHG emissions are not the sole privilege of the dominant class.

6 Conclusion

In this paper, we aimed at delineating a typology of carbon voluntarisms in terms of a set of economic and socio-political underpinnings to replace the analysis of climate policies in the historical context of contemporary globalized finance-led capitalism. Our results are in line with our theoretical reasoning. They show that if income and capitalist development play a substantial role in the stance of countries towards GHG mitigation, we need to look beyond to have a more nuanced and complex representation. National economic interests appear to play a key role: the productive structure of the economies and their relative position in global GHG chains are to be taken into account to understand the path towards carbon voluntarism. National ecological preferences are an important factor too, as shown by the strength of the political demand for the environment in the more ambitious countries for GHG mitigation. Results for internal class dynamics show that a more equal class structure of emissions acts in favor of carbon voluntarism while financialization appears to be a brake: the weaker functional financialization and financial accumulation, the greater carbon voluntarism.

From these results, we delineated a typology of carbon voluntarisms from *very low* to *average*. The least carbon voluntary countries appear to be at the beginning of global GHG chains, to rely heavily on the primary sector, to have a weaker political demand for the environment and to have a highly unequal class structure of emissions. The most carbon voluntary countries have a higher political demand for the environment, a more equal class structure of emissions, financialization is weaker, they rely to a great extent on the tertiary sector and they import an important part of their GHG emissions. As such, this article is then a complement to the existing game theory literature on international environmental agreements: Our results shed light on the underpinnings of the behaviors of the States in taking into account economic and socio-political factors whose combination and interactions produce carbon voluntarism. A promising research avenue would be to investigate further national institutional arrangements for the environment such as concrete measures of climate policies, the extent to which they reflect carbon voluntarism, and their correspondence to models of capitalism.

In terms of public policy, a conclusion arising from this work is that global GHG chains should be taken into account in international climate negotiations and climate policies. A combination of measures would seem adequate: i.e. pushing for substantial financial and technological transfers to GHG exporting countries to assist them in shifting to a low-carbon economy or implementing carbon and kilometers taxes on imports to help relocating activities to more stringent countries in terms of GHG regulations. This work also shows that reducing inequalities and financialization dynamics might be sound policies to improve the social basis of climate policies.

Acknowledgments

I am indebted to Cédric Durand, Marc Lavoie, Julien Vauday, Robert Guttmann as well as to the participants of the PhD students seminar of the CEPN for very valuable comments and discussion on earlier drafts of this paper. All remaining errors are mine.

References

Amable, B. (2005) *Les cinq capitalismes: diversité des systèmes économiques et sociaux dans la mondialisation*, Paris, Éditions du Seuil.

Amable, B. and Palombarini, S. (2008) 'A Neorealist Approach to Institutional Change and the Diversity of Capitalism', *Socio-Economic Review*, **7**, 123–143.

Angeriz, A., McCombie, J. S. L. and Roberts, M. (2009) 'Increasing Returns and the Growth of Industries in the EU Regions: Paradoxes and Conundrums', *Spatial Economic Analysis*, **4**, 127–148.

Apergis, N. (2016) 'Environmental Kuznets Curves: New Evidence on Both Panel and Country-Level CO2 Emissions', *Energy Economics*, **54**, 263–271.

Barrett, S. (1994) 'Self-Enforcing International Environmental Agreements', *Oxford Economic Papers*, 878–894.

Barrett, S. (2005) 'The Theory of International Environmental Agreements'. In Mäler, K.-G. and Vincent, J. R. (eds) *Handbook of Environmental Economics: Economywide and International Environmental Issues*, Elsevier, pp. 1457–1516.

van den Bergh, J. C. J. M., Ferrer-i-Carbonell, A. and Munda, G. (2000) 'Alternative Models of Individual Behaviour and Implications for Environmental Policy', *Ecological Economics*, **32**, 43–61.

Berthe, A. and Élie, L. (2015) 'Mechanisms Explaining the Impact of Economic Inequality on Environmental Deterioration', *Ecological Economics*, **116**, 191–200.

Bourdieu, P. (2000) *Pascalian Meditations*, Stanford, Calif, Stanford University Press.

Boyer, R. (2000) 'Is a Finance-Led Growth Regime a Viable Alternative to Fordism? A Preliminary Analysis', *Economy and Society*, **29**, 111–145.

Boyer, R. (2015) *Économie Politique Des Capitalismes*, Paris, La Découverte.

Chancel, L. and Piketty, T. (2015) *Carbon and Inequality: From Kyoto to Paris. Trends in the Global Inequality of Carbon Emissions (1998-2013) and Prospects for an Equitable Adaptation Fund*, Paris School of Economics.

Clévenot, M., Guy, Y. and Mazier, J. (2010) 'Investment and the Rate of Profit in a Financial Context: The French Case', *International Review of Applied Economics*, **24**, 693–714.

Cohen, B. J. (2007) 'The Transatlantic Divide: Why Are American and British IPE so Different?', *Review of International Political Economy*, **14**, 197–219.

Cordonnier, L. (2006) ‘Le Profit sans L’accumulation: La Recette Du Capitalisme Gouverné Par La Finance’, *Innovations, Cahiers d’économie de l’innovation*, 79–108.

Costantini, V., Sforna, G. and Zoli, M. (2016) ‘Interpreting Bargaining Strategies of Developing Countries in Climate Negotiations. A Quantitative Approach’, *Ecological Economics*, **121**, 128–139.

Dinda, S. (2004) ‘Environmental Kuznets Curve Hypothesis: A Survey’, *Ecological Economics*, **49**, 431–455.

Duménil, G. and Lévy, D. (2012) ‘Neoliberalism’. In Fine, B., Saad-Filho, A., and Boffo, M. (eds) *The Elgar companion to Marxist economics*, pp. 240–245.

Dünhaupt, P. (2011) *The Impact of Financialization on Income Distribution in the USA and Germany: A Proposal for a New Adjusted Wage Share*, IMK at the Hans Boeckler Foundation, Macroeconomic Policy Institute.

Dünhaupt, P. (2012) ‘Financialization and the Rentier Income Share – Evidence from the USA and Germany’, *International Review of Applied Economics*, **26**, 465–487.

Dünhaupt, P. (2013a) *The Effect of Financialization on Labor’s Share of Income*, Working Paper, Institute for International Political Economy Berlin.

Dünhaupt, P. (2013b) ‘Determinants of Functional Income Distribution : Theory and Empirical Evidence’, *Global Labour University working paper*.

Élie, L., Zuindeau, B., Bécue, M., Camara, M., Douai, A. and Meunié, A. (2012) ‘Approche Régulationniste de La Diversité Des Dispositifs Institutionnels Environnementaux Des Pays de l’OCDE’, *Revue de la régulation*, **12**.

Epstein, G. A. (2005) *Financialization and the World Economy*, Cheltenham etc., Edward Elgar.

European Commission (2016) *Factsheet on the Commission’s Proposal on Binding Greenhouse Gas Emission Reductions for Member States (2021-2030)*, Factsheet, European Union.

European Commission (n.d.) *EU ETS Handbook*, European Union.

Gowdy, J. M. and Mayumi, K. (2001) ‘Reformulating the Foundations of Consumer Choice Theory and Environmental Valuation’, *Ecological Economics*, **39**, 223–237.

Guillaud, E. and Palombarini, S. (2006) ‘Evolution Des Attentes Sociales et Comportement Électoral: France, 1978-2002’, *PSE Working Papers*.

Husson, F., Josse, J. and Pagès, J. (2010) ‘Analyse de Données Avec R: Complémentarité Des Méthodes D’analyse Factorielle et de Classification’. In *42èmes Journées de Statistique*.

Husson, M. (2010) ‘Le Partage de La Valeur Ajoutée En Europe’, *La Revue de l’IRES*.

IPCC (2014) *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (Eds.)].*, Geneva, Switzerland, Intergovernmental Panel on Climate Change.

Jayadev, A. (2007) ‘Capital Account Openness and the Labour Share of Income’, *Cambridge Journal of Economics*, **31**, 423–443.

Jayadev, A. and Epstein, G. (2007) ‘The Correlates of Rentier Returns in OECD Countries’.

Jessop, B. (2014) ‘Capitalist Diversity and Variety: Variegation, the World Market, Compossibility and Ecological Dominance’, *Capital & Class*, **38**, 45–58.

Kaldor, N. (1975) ‘Economic Growth and the Verdoorn Law: A Comment on Mr Rowthorn’s Article’, *The Economic Journal*, **85**, 891.

Knell, M. (2004) ‘Structure Change and the Kaldor-Verdoorn law in the 1990s’, *Revue d’économie industrielle*, **105**, 71–83.

Köhler, K., Guschanski, A. and Stockhammer, E. (2015) ‘How Does Financialisation Affect Functional Income Distribution? A Theoretical Clarification and Empirical Assessment’, *Post-Keynesian Economics Study Group Working Paper*, **1507**.

Krippner, G. R. (2005) ‘The Financialization of the American Economy’, *Socio-Economic Review*, **3**, 173–208.

Lavoie, M. (2014) *Post-Keynesian Economics: New Foundations*, Northampton, MA, Edward Elgar.

Lazonick, W. (2010) ‘Innovative Business Models and Varieties of Capitalism: Financialization of the U.S. Corporation’, *Business History Review*, **84**.

Lazonick, W. and O’Sullivan, M. (2000) ‘Maximizing Shareholder Value: A New Ideology for Corporate Governance’, *Economy and Society*, **29**, 13–35.

Lenglart, F., Lesieur, C. and Pasquier, J.-L. (2010) ‘Les Émissions de CO2 Du Circuit Économique En France’, *L’économie française*.

Lenzen, M., Moran, D., Kanemoto, K. and Geschke, A. (2013) ‘Building Eora: A Global Multi-Region Input-Output Database at High Country and Sector Resolution’, *Economic Systems Research*, **25**, 20–49.

Martinez-Alier, J. (2002) ‘Currents of Environmentalism’. In *The environmentalism of the poor: a study of ecological conflicts and valuation*, Cheltenham, Edward Elgar, pp. 1–15.

Martinez-Alier, J. (2014) ‘The Environmentalism of the Poor’, *Geoforum*, **54**, 239–241.

Martinez-Alier, J., Kallis, G., Veuthey, S., Walter, M. and Temper, L. (2010) ‘Social Metabolism, Ecological Distribution Conflicts, and Valuation Languages’, *Ecological Economics*, **70**, 153–158.

Millemaci, E. and Ofria, F. (2014) ‘Kaldor-Verdoorn’s Law and Increasing Returns to Scale: A Comparison across Developed Countries’, *Journal of Economic Studies*, **41**, 140–162.

Nordhaus, W. (2015) ‘Climate Clubs: Overcoming Free-Riding in International Climate Policy’, *American Economic Review*, **105**, 1339–1370.

O’Connor, J. (1988) ‘Capitalism, Nature, Socialism: A Theoretical Introduction’, *Capitalism Nature Socialism*, **1**.

Orhangazi, O. (2008) ‘Financialisation and Capital Accumulation in the Non-Financial Corporate Sector: A Theoretical and Empirical Investigation on the US Economy: 1973-2003’, *Cambridge Journal of Economics*, **32**, 863–886.

Peck, J. and Theodore, N. (2007) ‘Variegated Capitalism’, *Progress in Human Geography*, **31**, 731–772.

Peters, G. P. (2008) ‘From Production-Based to Consumption-Based National Emission Inventories’, *Ecological Economics*, **65**, 13–23.

Peters, G. P., Davis, S. J. and Andrew, R. (2012) ‘A Synthesis of Carbon in International Trade’, *Biogeosciences*, **9**, 3247–3276.

Peters, G. P., Minx, J. C., Weber, C. L. and Edenhofer, O. (2011) ‘Growth in Emission Transfers via International Trade from 1990 to 2008’, *Proceedings of the National Academy of Sciences*, **108**, 8903–8908.

Roberts, J. T., Parks, B. C. and Vásquez, A. A. (2004) ‘Who Ratifies Environmental Treaties and Why? Institutionalism, Structuralism and Participation by 192 Nations in 22 Treaties’, *Global Environmental Politics*, **4**, 22–64.

Roux, B. L. (2014) *Analyse Géométrique Des Données Multidimensionnelles*, Paris, : Dunod.

Sato, M. (2014) ‘Embodied Carbon in Trade: A Survey of the Empirical Literature’, *Journal of Economic Surveys*, **28**, 831–861.

Scruggs, L. A. (1998) ‘Political and Economic Inequality and the Environment’, *Ecological Economics*, **26**, 259–275.

Seo, H. J., Kim, H. S. and Kim, Y. C. (2012) ‘Financialization and the Slowdown in Korean Firms’ R&D Investment’, *Asian Economic Papers*, **11**, 35–49.

Stern, D. I. (2004) ‘Environmental Kuznets Curve’, *Encyclopedia of energy*.

Stockhammer, E. (2004) ‘Financialisation and the Slowdown of Accumulation’, *Cambridge Journal of Economics*, **28**, 719–741.

Stockhammer, E. (2006) ‘Shareholder Value Orientation and the Investment-Profit Puzzle’, *Journal of Post Keynesian Economics*, **28**, 193–215.

Stockhammer, E. (2010) ‘Financialization and the Global Economy’, *Political Economy Research Institute Working Paper*, **242**.

Stockhammer, E. (2012) *Why Have Wage Shares Fallen*, Geneva, International Labour Office.

Tulkens, H. (1997) ‘Cooperation vs. Free Riding in International Environmental Affairs: Two Approaches’. In Hanley, N. and Folmer, H. (eds) *Game theory and the Environment*, London, Edward Elgar.

Tulkens, H. (2015) ‘Internal vs. Core Coalitional Stability in the Environmental Externality Game: A Reconciliation’, *CORE Discussion Paper*.

United Nations Framework Convention on Climate Change (2015) *Adoption of the Paris Agreement (FCCC/CP/2015/L.9/Rev.1)*.

Van Alstine, J. and Neumayer, E. (2008) ‘The Environmental Kuznets Curve’. In Gallagher, K. P. (ed) *Handbook on Trade and the Environment*, p. 49.

Veblen, T. B. (1979) *Théorie de la classe de loisir*, Paris, Gallimard.

Vyas, S. and Kumaranayake, L. (2006) ‘Constructing Socio-Economic Status Indices: How to Use Principal Components Analysis’, *Health Policy and Planning*, **21**, 459–468.

Wisman, J. D. (2011) ‘Inequality, Social Respectability, Political Power, and Environmental Devastation’, *Journal of Economic Issues*, **0**, 877–900.

van der Zwan, N. (2014) ‘Making Sense of Financialization’, *Socio-Economic Review*, **12**, 99–129.

Varieties of carbon voluntarism in contemporary capitalism

Louison CAHEN-FOUROT

Centre d'Économie de Paris-Nord, Université Paris-13 Villetaneuse Sorbonne Paris Cité, 99 avenue Jean-Baptiste Clément 93430 Villetaneuse, France.

Email: louison.cahen-fourot@univ-paris13.fr

Appendixes. Supplementary material

Appendix 1. Raw data

Country	COP21 (%)	PrimAgri (%)	PrimIndus (%)	SecManuf (%)	SecConst (%)	Ter_Serv (%)	Ter_FIRE (%)	GDPCap	EmbCO2 (%)	IUCN	GreenP (%)	FinIndex (%)	WShare (%)	ClassGHG	Cluster
Brazil	112	5,1	7,00	13,90	6,3	53	15	14 635	12,31	0,10	0,02	21,09	50,29	14,42	1
Chile	222	3,5	13,80	11,00	7,8	43	5	23 794	1,74	0,17	0,04	25,28	44,83	8,50	1
China	255	9,7	6,90	30,10	6,9	33	13	13 705	-19,57	0,02	0,01	-9,00	56,72	9,65	1
India	442	17,6	4,10	14,90	8,1	38	17	5 494	-9,95	0,03	0,00	34,35	30,44	5,34	1
Mexico	35	3,3	9,20	17,80	7,4	47	15	17 931	3,95	0,16	0,02	46,85	38,60	10,10	1
Poland	-42	2,8	6,10	17,90	7,1	54	9	25 717	6,30	0,24	0,12	32,90	53,97	4,40	1
Slovakia	-46	4,3	4,20	20,30	8,1	51	11	28 472	42,38	0,18	0,12	31,48	49,42	3,43	1
Turkey	389	8,0	4,20	17,80	5,1	50	14	18 799	22,98	0,07	0,13	38,67	39,00	6,10	1
Australia	-5	2,5	9,90	6,80	8,8	50	22	49 636	10,17	1,28	0,21	14,98	58,80	5,49	2
Canada	8	1,5	9,80	10,70	7,2	52	19	46 228	4,95	0,62	0,25	15,98	63,36	6,81	2
Norway	-40	1,6	25,10	7,90	5,8	51	12	67 273	31,25	0,58	0,62	20,70	56,18	3,17	2
Russia	-11	4,2	13,70	15,60	6,5	42	18	24 044	-25,66	0,05	0,00	8,61	63,96	5,04	2
South Africa	20	2,5	12,10	13,30	4,1	47	21	14 460	-22,34	0,46	0,01	22,09	51,87	10,83	2
Austria	-23	1,4	3,10	18,00	6,2	56	15	48 457	32,81	0,59	0,12	16,76	63,70	3,39	3
Czech Republic	-50	2,6	5,60	25,50	5,4	47	13	30 400	1,65	0,48	0,09	26,13	51,71	3,06	3
Estonia	-75	3,4	5,70	15,50	6,4	55	14	29 155	-14,69	1,52	0,00	13,04	61,04	4,10	3
Germany	-51	0,7	3,00	21,80	4,4	54	15	46 617	5,14	0,30	0,72	19,21	62,79	3,75	3
Greece	-10	3,9	3,50	9,50	3,0	59	22	27 065	35,06	0,64	0,09	41,50	57,36	4,64	3
Hungary	-38	4,3	3,20	22,50	4,2	53	11	25 538	18,45	0,71	0,12	18,93	55,78	3,43	3
Ireland	-15	1,6	3,00	19,70	2,9	56	16	47 882	22,43	0,00	0,00	33,81	45,25	3,70	3
Israel	106	1,3	2,50	14,10	5,4	56	21	35 151	14,89	0,49	1,22	20,41	52,97	8,35	3
Italy	-33	2,1	3,10	15,30	4,9	54	20	34 622	21,42	0,36	0,14	30,23	61,59	4,54	3
Japan	-15	1,2	2,10	18,70	6,1	56	16	37 669	16,52	0,16	0,01	18,70	64,73	4,69	3
Portugal	4	2,3	3,70	12,90	4,4	58	18	26 738	23,06	0,48	0,00	28,79	59,27	4,82	3
Slovenia	-42	2,1	4,20	22,40	5,5	53	11	31 386	11,35	0,48	0,12	17,34	70,43	2,85	3

Country	COP21 (%)	PrimAgri (%)	PrimIndus (%)	SecManuf (%)	SecConst (%)	Ter_Serv (%)	Ter_FIRE (%)	GDPCap	EmbCO2 (%)	IUCN	GreenP (%)	FinIndex (%)	WShare (%)	ClassGHG	Cluster
South Korea	81	2,3	3,00	30,30	4,9	46	14	37 374	0,92	0,65	0,01	16,78	67,30	6,46	3
Spain	2	2,4	3,60	12,80	5,2	59	16	33 249	32,76	0,84	0,22	24,40	60,72	4,62	3
United Kingdom	-47	0,7	4,00	10,40	6,0	60	19	40 774	33,81	0,68	0,20	19,83	64,38	4,58	3
United States	-30	1,3	4,40	12,30	4,0	59	19	55 310	13,65	0,29	0,08	22,98	61,65	9,08	3
Belgium	-38	0,7	2,70	13,50	5,6	63	15	46 749	-8,36	1,16	0,85	15,86	66,80	3,57	4
Denmark	-45	1,5	4,60	13,20	4,5	59	17	45 512	36,64	1,77	0,62	14,08	66,13	3,10	4
Finland	-59	2,8	3,50	16,50	6,2	55	16	42 522	22,27	1,10	0,62	17,56	64,55	3,28	4
France	-40	1,6	2,50	11,00	5,6	62	17	39 152	32,34	0,91	0,25	12,24	66,97	3,94	4
Netherlands	-40	1,8	4,50	11,80	4,4	64	13	48 013	16,12	2,25	2,43	21,93	65,87	3,43	4
New Zealand	-11	6,1	5,40	11,90	5,7	50	21	37 173	10,21	2,00	1,11	21,60	54,80	5,90	4
Sweden	-38	1,3	3,40	15,40	5,7	59	13	47 426	47,71	1,13	0,62	8,59	62,74	3,30	4
Switzerland	-50	0,8	1,90	19,00	5,3	62	11	58 925	59,07	2,32	1,95	14,86	68,79	4,16	4
Overall mean	21	3,16	5,74	16,00	5,71	53,14	15,51	35 218	14,70	0,68	0,35	21,61	57,70	5,41	
Overall standard dev.	118	3,09	4,46	5,39	1,36	6,82	3,79	13 681	19,30	0,62	0,54	10,12	9,10	2,61	

Table 1. Raw data for the PCA, ordered by cluster and alphabetic order. For *EmbCO2*, a negative number means net exports of CO2.

Appendix 2. PCA Results

	Eigenvalue	Percentage of variance	Cumulative percentage of variance
comp 1	**4.59**	**35.29**	**35.29**
comp 2	**1.75**	**13.44**	**48.73**
comp 3	**1.62**	**12.48**	**61.21**
comp 4	**1.29**	**9.95**	**71.16**
comp 5	**1.12**	**8.59**	**79.75**
comp 6	0.76	5.84	85.59
comp 7	0.62	4.78	90.37
comp 8	0.42	3.25	93.62
comp 9	0.34	2.62	96.24
comp 10	0.21	1.63	97.87
comp 11	0.15	1.14	99.01
comp 12	0.09	0.72	99.73
comp 13	0.03	0.27	100
Total	**13**		
Mean		**7.69**	

Table 2. Eigenvalues, percentage of variance and cumulative percentage of variance for each axis. The axes fulfilling the selection threshold are in bold. To choose the number of axes to keep we followed the Keiser criterion: We kept the axes with an eigenvalue greater than the average. Since we performed a normalized PCA, the sum of eigenvalues is equal to the number of the active variables and so the average eigenvalue is 1. Axes 1 to 5 fulfil the Keiser criterion. We applied three other criteria to confirm our choice of keeping five axes: the Elbow, the Scree-Test and the average inertia (variance) criteria. Except for the Scree-test, which indicated to keep four axes, the two other criteria confirmed the choice of five axes. The Elbow criterion is a graphical analysis: We keep all the axes above and close to 1 until we observe a break before a continuous decrease in the eigenvalues. The Scree-test relies on the *n*th differences of eigenvalues: We keep all the axes for which the *n*th difference of eigenvalues is positive. Finally, according to the average inertia (or variance) criterion, we keep all axes whose inertia is above the average (here 7.69%).

Variables	Coordinate values					Square cosines					Sum of square cosines				Contributions				
	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Plan 1:2	Plan 1:3	Plan 1:4	Plan 1:5	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5
PrimAgri	-0.72	0.03	-0.07	0.19	0.52	0.53	0.00	0.01	0.04	0.27	0.53	0.53	0.56	0.79	11.45	0.06	0.31	2.94	23.92
PrimIndus	-0.30	-0.16	0.73	0.22	-0.40	0.09	0.03	0.53	0.05	0.16	0.12	0.62	0.14	0.25	2.02	1.53	32.42	3.63	14.13
SecManuf	-0.27	-0.49	-0.75	-0.08	-0.02	0.07	0.24	0.56	0.01	0.00	0.32	0.64	0.08	0.07	1.58	14.02	34.75	0.49	0.04
SecConst	-0.44	-0.33	0.37	0.42	0.07	0.19	0.11	0.14	0.18	0.00	0.30	0.33	0.37	0.20	4.24	6.20	8.33	13.66	0.42
Ter_Serv	0.87	0.34	-0.09	-0.02	-0.05	0.76	0.12	0.01	0.00	0.00	0.87	0.77	0.76	0.76	16.53	6.60	0.46	0.05	0.21
Ter_FIRE	0.10	0.45	0.33	-0.66	0.26	0.01	0.21	0.11	0.44	0.07	0.22	0.12	0.45	0.08	0.22	11.82	6.78	33.66	5.93
GDPCap	0.82	-0.11	0.21	0.10	-0.25	0.68	0.01	0.05	0.01	0.06	0.69	0.72	0.69	0.74	14.72	0.74	2.82	0.79	5.71
EmbCO2	0.63	0.33	-0.20	0.38	-0.12	0.40	0.11	0.04	0.14	0.01	0.51	0.44	0.55	0.42	8.77	6.29	2.43	11.04	1.31
IUCN	0.72	-0.16	0.21	0.16	0.51	0.52	0.03	0.04	0.02	0.26	0.55	0.56	0.55	0.78	11.39	1.46	2.60	1.87	23.05
GreenP	0.64	-0.10	0.15	0.27	0.50	0.41	0.01	0.02	0.07	0.25	0.42	0.44	0.49	0.66	9.00	0.61	1.42	5.77	22.48
ClassGHG	-0.55	0.11	0.31	-0.34	0.09	0.30	0.01	0.09	0.11	0.01	0.32	0.40	0.42	0.31	6.64	0.71	5.83	8.85	0.68
FinIndex	-0.23	0.82	-0.17	0.31	-0.10	0.05	0.68	0.03	0.10	0.01	0.73	0.08	0.15	0.06	1.15	38.86	1.86	7.49	0.96
WShare	0.75	-0.44	0.01	-0.36	-0.11	0.56	0.19	0.00	0.13	0.01	0.76	0.56	0.69	0.58	12.30	11.11	0.00	9.79	1.17

Table 3. Coordinates values, square cosines and contributions of the variables to the axes.

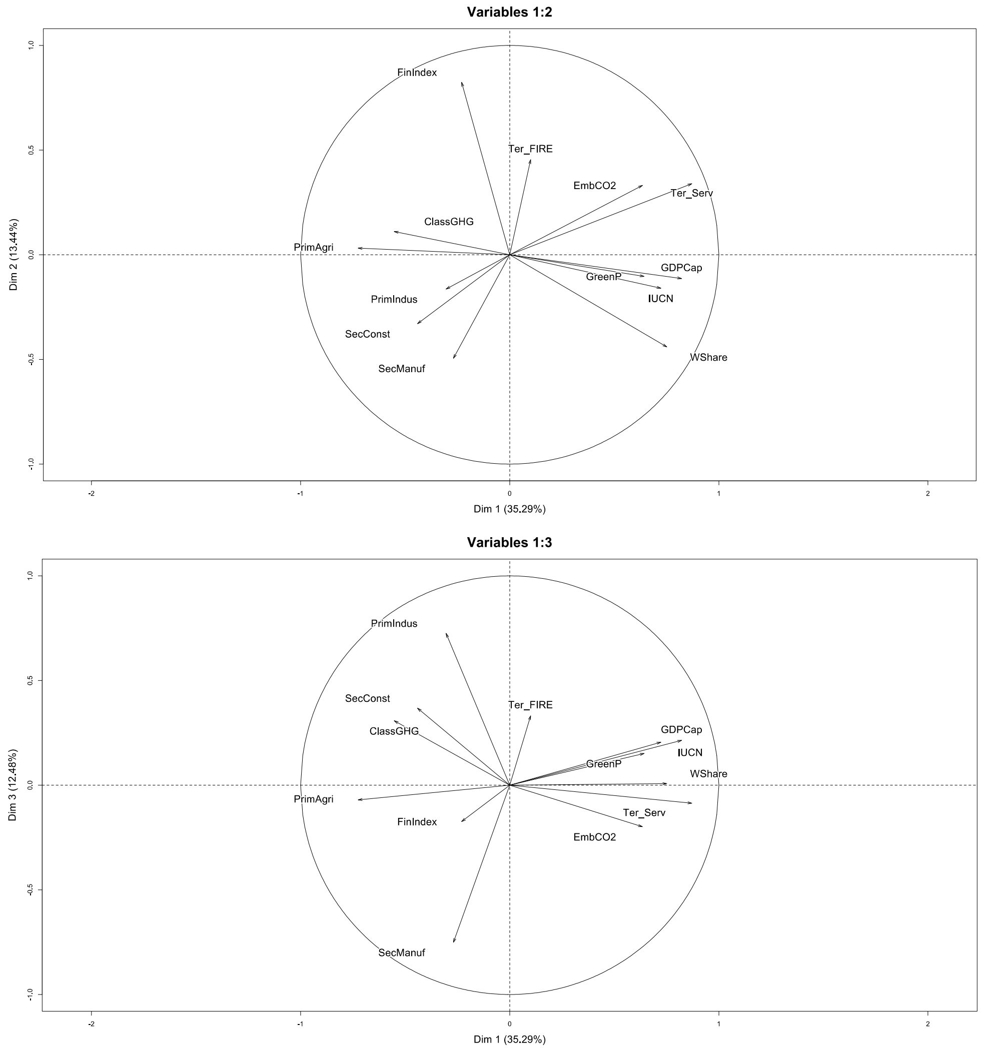

Figure 1. Plan 1:2 and 1:3 for the variables. The closer a variable to the unit circle, the better its quality of projection. The closer a variable to an axis, the greater its correlation with this axis: countries with a high absolute value for this axis will have a high absolute value for that variable.

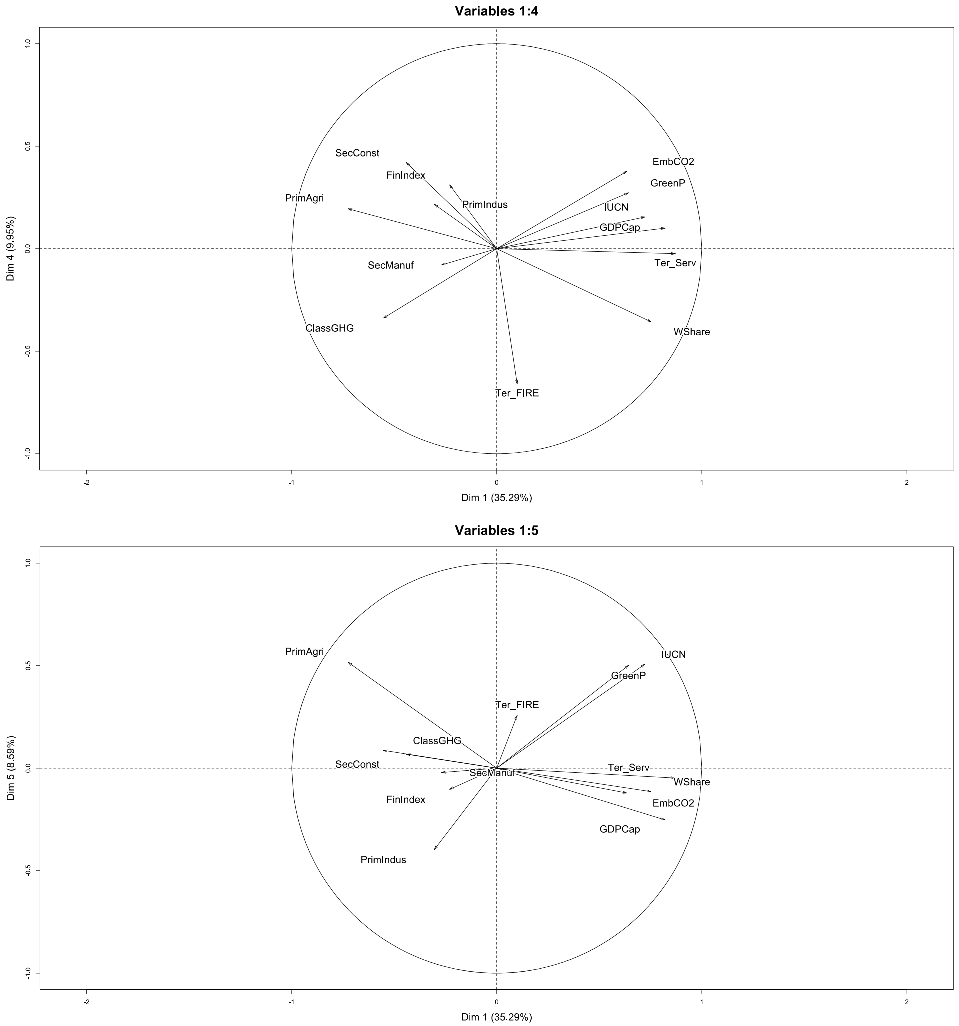

Figure 2. Plan 1:4 and 1:5 for the variables.

Countries	Coordinate values					Square cosines					Sum of square cosines				Contributions				
	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Plan 1:2	Plan 1:3	Plan 1:4	Plan 1:5	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5
Australia	0.26	-0.27	3.12	-0.02	0.34	0.00	0.01	0.66	0.00	0.01	0.01	0.66	0.00	0.01	0.04	0.12	16.25	0.00	0.27
Austria	1.27	-0.48	-0.66	0.13	-0.80	0.36	0.05	0.10	0.00	0.14	0.42	0.46	0.37	0.51	0.95	0.36	0.73	0.04	1.55
Belgium	2.12	-0.69	0.25	-0.47	0.40	0.51	0.06	0.01	0.03	0.02	0.57	0.52	0.54	0.53	2.65	0.74	0.10	0.46	0.38
Brazil	-2.60	0.75	0.83	-0.81	0.21	0.40	0.03	0.04	0.04	0.00	0.43	0.44	0.44	0.40	3.99	0.87	1.14	1.38	0.11
Canada	0.14	-0.44	2.08	-0.63	-0.52	0.00	0.03	0.71	0.07	0.04	0.03	0.71	0.07	0.05	0.01	0.30	7.21	0.84	0.66
Chile	-3.04	-0.74	1.38	2.29	-1.30	0.42	0.02	0.09	0.24	0.08	0.44	0.50	0.65	0.49	5.45	0.85	3.18	10.92	4.07
China	-4.31	-4.02	-0.66	-1.31	1.12	0.46	0.40	0.01	0.04	0.03	0.86	0.47	0.50	0.49	10.96	24.96	0.73	3.56	3.03
Czech Republic	-1.14	-0.70	-1.57	0.34	-0.52	0.19	0.07	0.37	0.02	0.04	0.27	0.56	0.21	0.23	0.77	0.75	4.11	0.24	0.66
Denmark	2.84	-0.08	0.16	-0.10	0.50	0.83	0.00	0.00	0.00	0.03	0.83	0.83	0.83	0.85	4.74	0.01	0.04	0.02	0.62
Estonia	-0.04	-1.31	0.37	-0.28	0.59	0.00	0.27	0.02	0.01	0.05	0.27	0.02	0.01	0.06	0.00	2.65	0.23	0.17	0.85
Finland	1.34	-0.59	-0.15	0.21	0.45	0.60	0.12	0.01	0.02	0.07	0.72	0.61	0.62	0.67	1.06	0.54	0.04	0.09	0.48
France	2.00	0.12	0.09	-0.52	-0.08	0.59	0.00	0.00	0.04	0.00	0.59	0.59	0.63	0.59	2.36	0.02	0.01	0.56	0.01
Germany	1.01	-0.68	-1.18	-0.68	-0.49	0.18	0.08	0.25	0.08	0.04	0.26	0.43	0.26	0.22	0.60	0.72	2.31	0.97	0.59
Greece	0.75	3.40	-0.45	-0.91	0.12	0.04	0.77	0.01	0.05	0.00	0.80	0.05	0.09	0.04	0.33	17.86	0.34	1.72	0.04
Hungary	-0.21	-0.54	-2.03	0.27	-0.04	0.01	0.05	0.68	0.01	0.00	0.06	0.69	0.02	0.01	0.03	0.45	6.84	0.15	0.00
India	-5.69	1.18	-0.20	1.60	2.79	0.66	0.03	0.00	0.05	0.16	0.69	0.67	0.72	0.82	19.08	2.17	0.07	5.34	18.83
Ireland	0.24	1.83	-1.81	-0.25	-1.28	0.00	0.28	0.27	0.01	0.14	0.28	0.28	0.01	0.14	0.03	5.16	5.45	0.13	3.96
Israel	0.55	0.98	0.53	-1.01	1.07	0.04	0.13	0.04	0.14	0.15	0.17	0.08	0.18	0.19	0.18	1.48	0.46	2.12	2.75
Italy	0.38	1.24	-0.50	-0.93	-0.32	0.04	0.40	0.07	0.23	0.03	0.44	0.10	0.26	0.06	0.09	2.38	0.42	1.81	0.25
Japan	0.38	-0.31	-0.86	-0.73	-0.82	0.04	0.03	0.21	0.15	0.19	0.07	0.25	0.19	0.24	0.09	0.15	1.23	1.10	1.64
Mexico	-3.38	1.72	0.38	0.94	-0.38	0.57	0.15	0.01	0.04	0.01	0.72	0.58	0.62	0.58	6.74	4.56	0.24	1.84	0.36
Netherlands	3.99	-0.28	0.59	1.25	2.24	0.57	0.00	0.01	0.06	0.18	0.57	0.58	0.62	0.75	9.39	0.12	0.58	3.25	12.15
New Zealand	0.62	0.38	1.37	-0.03	2.61	0.04	0.01	0.18	0.00	0.65	0.05	0.22	0.04	0.69	0.23	0.22	3.15	0.00	16.45
Norway	0.97	-0.48	3.29	2.28	-2.61	0.03	0.01	0.37	0.18	0.23	0.04	0.40	0.21	0.26	0.55	0.36	17.98	10.84	16.43
Poland	-1.19	-0.09	-0.78	1.48	-0.88	0.20	0.00	0.08	0.31	0.11	0.20	0.28	0.51	0.31	0.84	0.01	1.00	4.57	1.89
Portugal	0.38	1.53	-0.51	-0.75	-0.36	0.03	0.56	0.06	0.14	0.03	0.60	0.10	0.17	0.07	0.08	3.62	0.44	1.18	0.32

Countries	Coordinate values					Square cosines					Sum of square cosines				Contributions				
	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Plan 1:2	Plan 1:3	Plan 1:4	Plan 1:5	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5
Russia	-2.17	-1.85	1.58	-1.31	-0.56	0.30	0.22	0.16	0.11	0.02	0.53	0.47	0.42	0.32	2.77	5.32	4.18	3.61	0.75
Slovakia	-1.13	0.20	-1.28	2.28	-0.57	0.12	0.00	0.15	0.47	0.03	0.12	0.26	0.59	0.14	0.75	0.06	2.72	10.90	0.79
Slovenia	0.36	-1.55	-1.52	-0.08	-0.83	0.02	0.36	0.35	0.00	0.10	0.38	0.37	0.02	0.12	0.08	3.69	3.84	0.01	1.65
South Africa	-2.34	0.73	1.61	-2.36	0.03	0.31	0.03	0.15	0.31	0.00	0.34	0.45	0.62	0.31	3.22	0.83	4.34	11.61	0.00
South Korea	-0.52	-1.93	-1.88	-1.28	-0.36	0.02	0.32	0.31	0.14	0.01	0.35	0.33	0.17	0.03	0.16	5.76	5.87	3.45	0.32
Spain	1.06	0.91	-0.31	0.02	-0.12	0.39	0.29	0.03	0.00	0.01	0.68	0.42	0.39	0.40	0.66	1.28	0.16	0.00	0.04
Sweden	2.39	-0.74	-0.39	0.75	-0.13	0.64	0.06	0.02	0.06	0.00	0.70	0.66	0.70	0.64	3.37	0.84	0.26	1.19	0.04
Switzerland	4.58	-1.11	-0.56	1.78	1.46	0.68	0.04	0.01	0.10	0.07	0.72	0.69	0.78	0.75	12.38	1.89	0.53	6.60	5.13
Turkey	-2.40	1.93	-1.34	1.08	0.43	0.44	0.28	0.14	0.09	0.01	0.72	0.57	0.53	0.45	3.39	5.78	2.98	2.46	0.45
United Kingdom	1.59	0.80	0.50	-0.50	-0.46	0.44	0.11	0.04	0.04	0.04	0.55	0.49	0.49	0.48	1.48	0.98	0.42	0.52	0.52
United States	0.94	1.17	0.50	-1.74	-0.90	0.10	0.15	0.03	0.33	0.09	0.25	0.12	0.43	0.19	0.52	2.13	0.42	6.32	1.96

Table 4. Coordinates values, square cosines and contributions of the countries to the axes. The greater its coordinate on an axis, the greater the country's contribution to this axis.

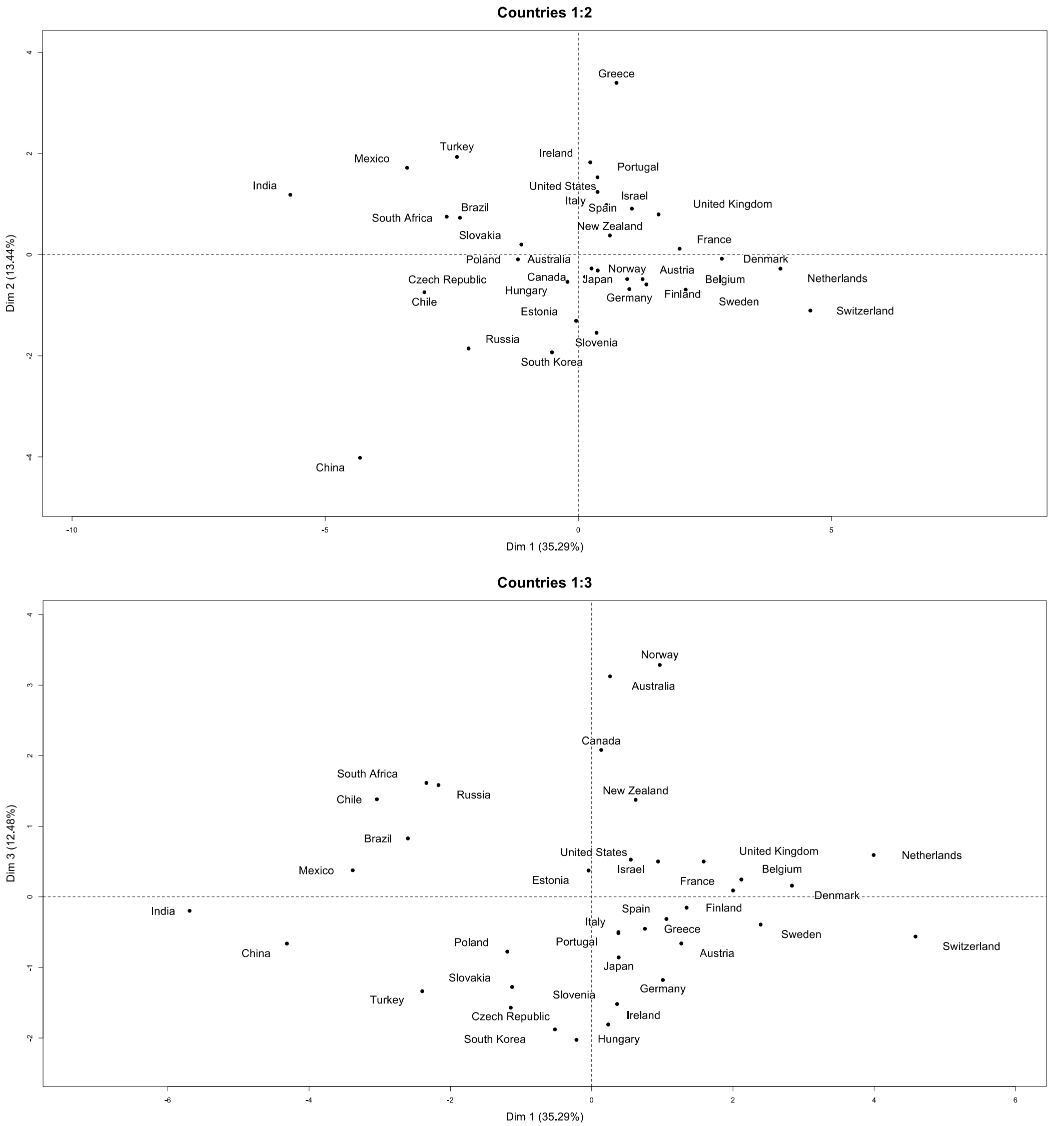

Figure 3. Plan 1:2 to 1:5 for the countries. Countries with a high absolute value for an axis will have a high absolute value for the correlated variables.

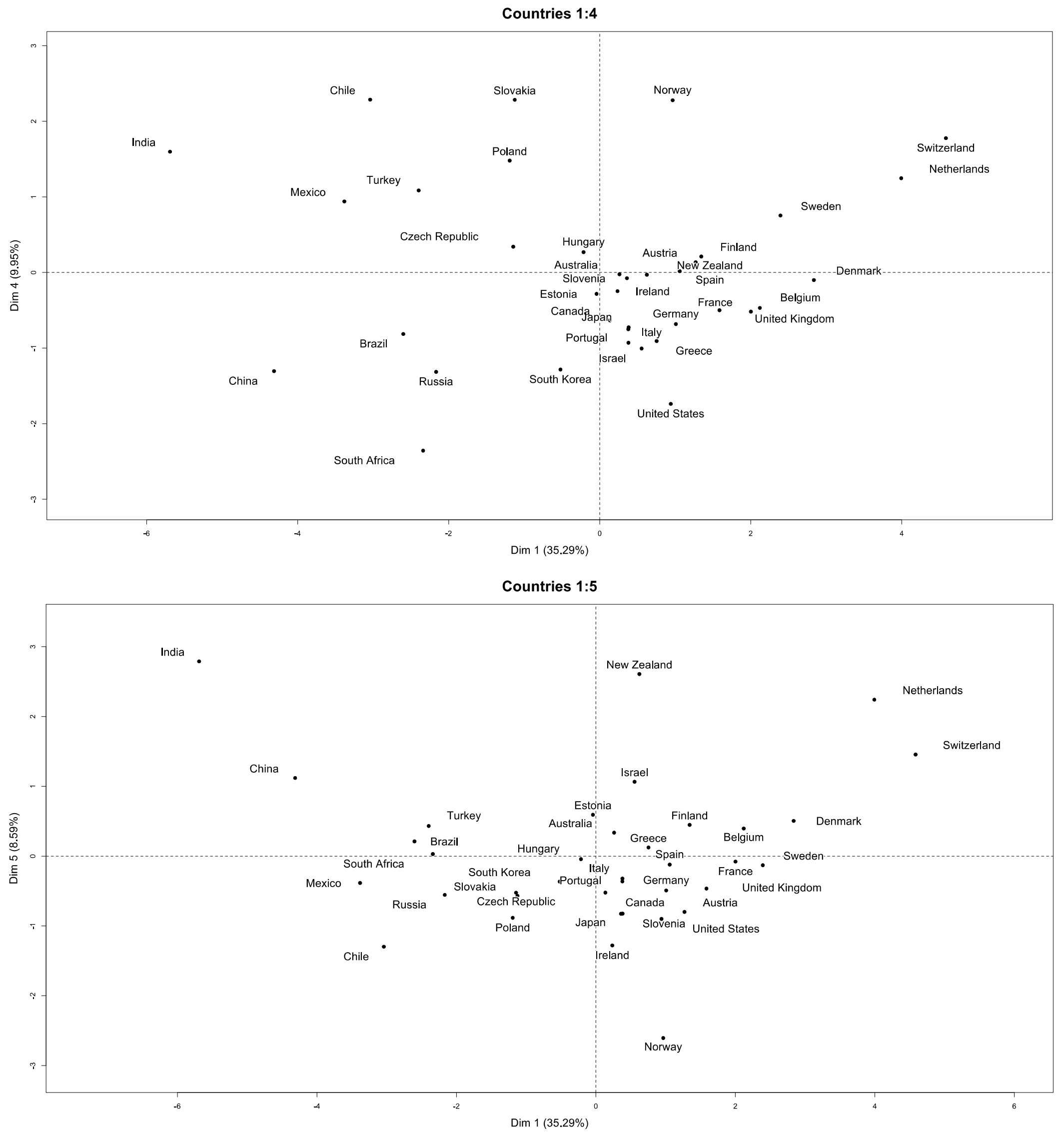

Figure 4. Plan 1:4 to 1:5 for the countries

Pearson correlations	PrimAgri	PrimIndus	SecManuf	SecConst	Ter_Serv	Ter_FIRE	GDPCap	GreenP	EmbCO2	IUCN	FinIndex	WShare	ClassGHG
PrimAgri	1	0.029	0.159	0.35**	-0.670***	-0.021	-0.672***	-0.246	-0.363**	-0.288	0.142	-0.660***	0.232
PrimIndus	0.029	1	-0.336**	0.309*	-0.43***	-0.124	0.040	-0.133	-0.295*	-0.172	-0.050	-0.208	0.234
SecManuf	0.159	-0.336**	1	-0.073	-0.392**	-0.423***	-0.261	-0.183	-0.207	-0.273	-0.181	-0.004	-0.038
SecConst	0.354**	0.309*	-0.073	1	-0.475***	-0.228	-0.233	-0.182	-0.230	-0.138	-0.124	-0.264	0.161
Ter_Serv	-0.670***	-0.43***	-0.392**	-0.475***	1	0.135	0.601***	0.460***	0.641***	0.516***	0.071	0.538***	-0.398***
Ter_FIRE	-0.021	-0.124	-0.42***	-0.228	0.135	1	0.046	-0.048	-0.072	0.066	0.054	0.08	0.166
GDPCap	-0.672***	0.040	-0.261	-0.233	0.601***	0.046	1	0.500***	0.510***	0.501***	-0.257	0.594***	-0.468***
EmbCO2	-0.363**	-0.295*	-0.20	-0.230	0.641***	-0.072	0.510***	0.314*	1	0.327**	0.164	0.228	-0.401***
GreenP	-0.246	-0.133	-0.183	-0.182	0.460***	-0.048	0.500***	1	0.314*	0.750***	-0.165	0.321**	-0.232
IUCN	-0.288*	-0.172	-0.273	-0.138	0.516***	0.066	0.501***	0.750***	0.327**	1	-0.290*	0.499***	-0.357**
FinIndex	0.142	-0.050	-0.181	-0.124	0.071	0.054	-0.257	-0.165	0.164	-0.290*	1	-0.614***	0.042
WShare	-0.660***	-0.208	-0.004	-0.264	0.538***	0.089	0.594***	0.321**	0.228	0.499***	-0.614***	1	-0.39**
ClassGHG	0.232	0.234	-0.038	0.161	-0.398***	0.166	-0.468***	-0.232	-0.401***	-0.357**	0.042	-0.39**	1

Table 5. Correlations matrix for the PCA. Significant at 1% level:*. Significant at 5% level:**. Significant at 10% level:*.**

Appendix 3. Results of the clustering

Cluster	Axis	COP21 (%)	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5
1	Mean	171	-2.97			0.94	
	St. dev.	175	1.43			1.25	
2	Mean	-6			2.34		
	St. dev.	20			0.73		
3	Mean	-15			-0.71	-0.52	
	St. dev.	46			0.86	0.57	
4	Mean	-40	2.49				0.93
	St. dev.	13	1.22				0.98

Table 6. Characterization of the clusters by the axes obtained from the PCA.

Cluster	Variables	PrimAgri	PrimIndus	SecManuf	SecConst	Ter_Serv	Ter_FIRE	GDPCap	EmbCO2	IUCN	GreenP	FinIndex	Wshare	ClassGHG
1	Test value	3.7			3.2	-3.2	-2.6	-3.8		-2.9			-4.3	2.8
2			4.5	-2.3										
3			-2.5		-3.0									
4						2.8		2.4	2.0	4.6	4.1		2.4	

Table 7. Test-values from the clustering. The test value shows the significance of a variable to characterize a class: if the absolute value of the v-test is higher than 1.96 then the values of the variable *i* for the class *j* are not random and the variable is statistically significant for this class. The greater the absolute test value, the more significant the variable *i* for the class *j*. A negative test value indicates that the value of the variable for this class is below the overall mean, while a positive test value indicates that the variable is above the overall mean.

Appendix 4. R code for the PCA and the clustering

```
###Workfile directory###
setwd("Pathway to workfile directory")
###FactoMineR package###
library(FactoMineR)
###Importing the data from the csv file###
v11_strucprod <- read.table("Pathway to csv datafile", header=TRUE, sep=";", na.strings="NA", dec=",", row.names=1,
  strip.white=TRUE)
summary(v11_strucprod)
###Correlations matrix###
library(lattice, pos=17)
library(survival, pos=17)
library(Formula, pos=17)
library(ggplot2, pos=17)
library(Hmisc, pos=17)
rcorr.adjust(Données[,c("ClassGHG","EmbCO2","FinIndex","GDPCap","GreenP","IUCN","PrimAgri","PrimIndus","SecConst","SecManuf","Ter_FIRE","Ter_Serv","WShare")], type="pearson", use="complete")
###PCA###
Strucprod.PCA<-v11_strucprod[, c("PrimAgri", "PrimIndus", "SecManuf", "SecConst", "Ter_Serv", "Ter_FIRE", "GDPCap", "EmbCO2", "IUCN", "GreenP", "ClassGHG", "FinIndex", "WShare")]
Strucprod_res<-PCA(Strucprod.PCA , scale.unit=TRUE, ncp=13, graph = FALSE)
###Plotting the results###
plot.PCA(Strucprod_res, axes=c(1, 2), choix="ind", cex=1.5, cex.main=2, cex.lab=1.5, habillage="none", col.ind="black", col.ind.sup="blue", col.quali="magenta", label=c("ind", "ind.sup", "quali"),new.plot=TRUE, title="Countries 1:2", shadow=TRUE, auto="y")
plot.PCA(Strucprod_res, axes=c(1, 2), choix="var", cex=1.5, cex.main=2, cex.lab=1.5, new.plot=TRUE, col.var="black", col.quanti.sup="blue", label=c("var", "quanti.sup"), lim.cos2.var=0, title="Variables 1:2",shadow=TRUE, auto="y")
plot.PCA(Strucprod_res, axes=c(1, 3), choix="ind", cex=1.5, cex.main=2, cex.lab=1.5, habillage="none", col.ind="black", col.ind.sup="blue", col.quali="magenta", label=c("ind", "ind.sup", "quali"),new.plot=TRUE, title="Countries 1:3",shadow=TRUE, auto="y")
plot.PCA(Strucprod_res, axes=c(1, 3), choix="var", cex=1.5, cex.main=2, cex.lab=1.5, new.plot=TRUE, col.var="black", col.quanti.sup="blue", label=c("var", "quanti.sup"), lim.cos2.var=0, title="Variables 1:3",shadow=TRUE, auto="y")
plot.PCA(Strucprod_res, axes=c(1, 4), choix="ind", cex=1.5, cex.main=2, cex.lab=1.5, habillage="none", col.ind="black", col.ind.sup="blue", col.quali="magenta", label=c("ind", "ind.sup", "quali"),new.plot=TRUE, title="Countries 1:4",shadow=TRUE, auto="y")
plot.PCA(Strucprod_res, axes=c(1, 4), choix="var", cex=1.5, cex.main=2, cex.lab=1.5, new.plot=TRUE, col.var="black", col.quanti.sup="blue", label=c("var", "quanti.sup"), lim.cos2.var=0, title="Variables 1:4",shadow=TRUE, auto="y")
plot.PCA(Strucprod_res, axes=c(1, 5), choix="ind", cex=1.5, cex.main=2, cex.lab=1.5, habillage="none", col.ind="black", col.ind.sup="blue", col.quali="magenta", label=c("ind", "ind.sup", "quali"),new.plot=TRUE, title="Countries 1:5",shadow=TRUE, auto="y")
plot.PCA(Strucprod_res, axes=c(1, 5), choix="var", cex=1.5, cex.main=2, cex.lab=1.5, new.plot=TRUE, col.var="black", col.quanti.sup="blue", label=c("var", "quanti.sup"), lim.cos2.var=0, title="Variables 1:5",shadow=TRUE, auto="y")
###Summarizing the results and writing in a csv file###
summary(Strucprod_res, nb.dec = 3, nbelements=10, nbind = 10, ncp = 3, file="")
write.infile(Strucprod_res$eig, file ="v11_Strucprod_res",append=FALSE)
write.infile(Strucprod_res$var, file ="v11_Strucprod_res",append=TRUE)
write.infile(Strucprod_res$ind, file ="v11_Strucprod_res",append=TRUE)
write.infile(dimdesc(Strucprod_res, axes=1:13), file ="v11_Strucprod_res",append=TRUE)
remove(Strucprod.PCA)
###Clustering on the selected axes from the PCA###
v11_strucprod.PCA<-v11_strucprod[, c("PrimAgri", "PrimIndus", "SecManuf", "SecConst", "Ter_Serv", "Ter_FIRE", "GDPCap", "EmbCO2", "IUCN", "GreenP", "ClassGHG", "FinIndex", "WShare")]
res<-PCA(v11_strucprod.PCA , scale.unit=TRUE, ncp=5, graph = FALSE)
res.hcpc<-HCPC(res ,nb.clust=0,consol=TRUE,min=3,max=10,graph=TRUE)
res.hcpc$data.clust[,ncol(res.hcpc$data.clust),drop=F]
res.hcpc$desc.var
res.hcpc$desc.axes
res.hcpc$desc.ind
res.hcpc$call$t
summary(res, nb.dec = 3, nbelements = 13, nbind = 37, ncp = 4, file="v11_classi_res")
write.infile(res.hcpc$data.clust, file ="v11_classi_res",append=FALSE)
write.infile(res.hcpc$desc.var, file ="v11_classi_res",append=TRUE)
#write.infile(res.hcpc$desc.ind, file ="v11_classi_res",append=TRUE)
write.infile(res.hcpc$desc.axes, file ="v11_classi_res",append=TRUE)
write.infile(res.hcpc$call$t, file ="v11_classi_res",append=TRUE)
remove(v11_strucprod.PCA)
```

Appendix 5. EU countries' individual COP21 objectives

The INDC submitted by the European Union stated a common objective of a 40% reduction GHG emissions by 2030 compared to 1990, which encompassed all the sectors of the economy. On July 20th 2016, the European Commission released preliminary national emissions targets for 2030 regarding the sectors not covered by the EU Emissions Trading System (EUETS): agriculture, construction, waste management, transportation, CO_2 capture and storage as well as LULUCF. These sectors are to reduce their total emissions by 30% relative to 2005. The sectors included in the EUETS are subject to an objective of a 43% reduction in emissions by 2030 relatively to 2005 (European Commission, 2016). These sectors are

> "*heavy energy-using installations consisting of power stations and other combustion plants with ≥ 20MW thermal rated input (except hazardous or municipal waste installations), oil refineries, coke ovens, iron and steel, cement clinker, glass, lime, bricks, ceramics, pulp, paper and board, aluminium, petrochemicals, ammonia, nitric, adipic and glyoxylic acid production, CO_2 capture, transport in pipelines and geological storage of CO_2. The aviation scope of the EU ETS is limited to flights within the EEA until 2016 (...).*" (European Commission, n.d., p. 20)

To calculate the value of the *COP21* variable for the EU countries of our sample, we first computed the share of the ETS sectors in 2005 total emissions and deducted the share of the non-ETS sectors using UNFCC and Eurostat aggregate and sectorial emissions data. We then applied the announced mitigation rates to obtain 2030 emissions and finally computed the mitigation equivalencies in terms of 1990 emissions. The table below details the data and computations. Our results are consistent with the data provided by the European Commission and the INDC: a share of roughly 60% of the non-ETS sectors in total emissions, respective mitigations for ETS and non-ETS sectors of 43% and 32% relatively to 2005 and a overall mitigation of 40% of 1990 emissions by 2030 upon the total emissions of all the EU countries of our sample.

Label	1. Share of ETS sectors in total 2005 emissions	2. Share of non-ETS sectors in total 2005 emissions [1 - (1)]	3. Total 2005 emissions	4. ETS sectors 2005 emissions [(1)*(3)]	5. Non-ETS sectors 2005 emissions [(2)*(3)]	6. ETS sectors 2030 target in % of 2005	7. Non-ETS sectors 2030 target in % of 2005	8. ETS absolute mitigation by 2030 [(4)*(6)]	9. Non-ETS absolute mitigation by 2030 [(5)*(7)]	10. Total absolute mitigation by 2030 [(8) + (9)]	11. 2030 total emissions [(3) - (10)]	12. Total mitigation by 2030 in % of 2005 [((11) - (3))/(3)]	13. Total 1990 Emissions	14. Total mitigation by 2030 in % of 1990 [((11) - (13))/(13)]
Austria	29,9%	70,1%	84 956	25 381	59 574	43%	36%	10 914	21 447	32 361	52 595	-38,1%	68 209	**-22,9%**
Belgium	30,5%	69,5%	140 889	43 035	97 854	43%	35%	18 505	34 249	52 754	88 135	-37,4%	142 118	**-38,0%**
Czech Republic	56,5%	43,5%	139 543	78 774	60 769	43%	14%	33 873	8 508	42 380	97 162	-30,4%	192 708	**-49,6%**
Denmark	35,6%	64,4%	70 065	24 924	45 141	43%	39%	10 717	17 605	28 322	41 743	-40,4%	75 303	**-44,6%**
Estonia	96,1%	3,9%	13 432	12 907	525	43%	13%	5 550	68	5 618	7 814	-41,8%	31 806	**-75,4%**
Finland	79,6%	20,4%	40 059	31 890	8 169	43%	39%	13 713	3 186	16 899	23 160	-42,2%	56 654	**-59,1%**
France	25,6%	74,4%	522 761	133 936	388 825	43%	37%	57 592	143 865	201 458	321 304	-38,5%	531 764	**-39,6%**
Germany	43,5%	56,5%	1 003 577	436 307	567 270	43%	38%	187 612	215 562	403 175	600 402	-40,2%	1 223 531	**-50,9%**
Greece	51,3%	48,7%	132 641	68 073	64 568	43%	16%	29 272	10 331	39 602	93 039	-29,9%	102 821	**-9,5%**
Hungary	32,1%	67,9%	73 367	23 536	49 830	43%	7%	10 121	3 488	13 609	59 758	-18,5%	95 636	**-37,5%**
Ireland	25,5%	74,5%	67 442	17 219	50 223	43%	30%	7 404	15 067	22 471	44 971	-33,3%	52 934	**-15,0%**
Italy	40,0%	60,0%	544 715	217 690	327 026	43%	33%	93 607	107 919	201 525	343 190	-37,0%	515 446	**-33,4%**
Netherlands	39,8%	60,2%	211 729	84 206	127 522	43%	36%	36 209	45 908	82 117	129 612	-38,8%	214 863	**-39,7%**
Poland	57,4%	42,6%	353 943	203 066	150 877	43%	7%	87 318	10 561	97 880	256 063	-27,7%	440 865	**-41,9%**
Portugal	37,2%	62,8%	86 071	31 988	54 083	43%	17%	13 755	9 194	22 949	63 122	-26,7%	60 920	**3,6%**
Slovakia	39,6%	60,4%	45 847	18 172	27 675	43%	12%	7 814	3 321	11 135	34 712	-24,3%	64 595	**-46,3%**
Slovenia	70,9%	29,1%	15 035	10 662	4 373	43%	15%	4 585	656	5 241	9 794	-34,9%	16 960	**-42,3%**
Spain	43,4%	56,6%	399 209	173 397	225 812	43%	26%	74 561	58 711	133 272	265 937	-33,4%	260 444	**2,1%**
Sweden	57,5%	42,5%	36 011	20 722	15 288	43%	40%	8 911	6 115	15 026	20 985	-41,7%	34 027	**-38,3%**
United Kingdom	37,1%	62,9%	682 587	253 297	429 290	43%	37%	108 917	158 837	267 755	414 832	-39,2%	785 291	**-47,2%**
		Share of ETS and non ETS sectors in total 2005 emissions		**40,9%**	**59,1%**	**ETS and non-ETS mitigation in % of ETS and non-ETS 2005 emissions**		**43%**	**32%**	**Total mitigation in % of total 2005 emissions**		**-36,4%**	**Total mitigation in % of total 1990 emissions**	**-40,2%**

Table 8. Calculations of EU members individual mitigation objective, taking into account objective for both ETS and non-ETS sectors. Sources: calculus from the author based on emissions data from Eurostat and UNFCC and mitigations data from the European Commission.

Appendix 6. Comparisons of the varieties of carbon voluntarism with the IPCC benchmark

Clusters	Countries	2010 emissions	Mitigation according to IPCC scenario RCP2.6	2050 emissions following scenario RCP2.6	Average annual mitigation rate 2010-2050	2030 emissions at average annual mitigation rate 2010-2050	Mitigation 2010-2030 in % of 2010	1990 emissions	IPCC mitigation 2030-1990 in % of 1990	IPCC clusters average (%)	COP21 clusters average (%)	Carbon voluntarism
1	Brazil	2 902 243	55%	1 306 009	**-2,0%**	1 946 883	2,0%	1 606 209	**21%**	3	171	Very Low
	Chile	114 285	80%	22 857	**-3,9%**	51 109	4,1%	54 730	**-7%**			
	China	11 183 811	55%	5 032 715	**-2,0%**	7 502 327	2,0%	3 892 675	**93%**			
	India	2 771 457	55%	1 247 156	**-2,0%**	1 859 149	2,0%	1 387 372	**34%**			
	Mexico	643 375	55%	289 519	**-2,0%**	431 588	2,0%	494 151	**-13%**			
	Poland	426 486	80%	85 297	**-3,9%**	190 729	4,1%	474 016	**-60%**			
	Slovakia	49 973	80%	9 995	**-3,9%**	22 348	4,1%	72 262	**-69%**			
	Turkey	422 722	55%	190 225	**-2,0%**	283 569	2,0%	224 459	**26%**			
2	Australia	782 103	80%	156 421	**-3,9%**	349 766	4,1%	482 298	**-27%**	-42	-6	Low
	Canada	764 138	80%	152 828	**-3,9%**	341 732	4,1%	608 685	**-44%**			
	Norway	65 710	80%	13 142	**-3,9%**	29 385	4,1%	67 466	**-56%**			
	Russia	2 603 290	80%	520 658	**-3,9%**	1 164 226	4,1%	3 593 582	**-68%**			
	South Africa	456 538	55%	205 442	**-2,0%**	306 254	2,0%	349 202	**-12%**			
3	Austria	94 172	80%	18 834	**-3,9%**	42 114	4,1%	79 837	**-47%**	-51	-15	Low
	Czech Republic	145 707	80%	29 141	**-3,9%**	65 161	4,1%	196 207	**-67%**			
	Estonia	22 767	80%	4 553	**-3,9%**	10 181	4,1%	55 787	**-82%**			
	Germany	948 007	80%	189 601	**-3,9%**	423 961	4,1%	1 256 074	**-66%**			
	Greece	107 506	80%	21 501	**-3,9%**	48 077	4,1%	96 659	**-50%**			
	Hungary	66 251	80%	13 250	**-3,9%**	29 627	4,1%	97 552	**-70%**			
	Ireland	65 591	80%	13 118	**-3,9%**	29 332	4,1%	65 583	**-55%**			
	Israel	79 072	80%	15 814	**-3,9%**	35 361	4,1%	39 609	**-11%**			
	Italy	489 460	80%	97 892	**-3,9%**	218 892	4,1%	508 765	**-57%**			
	Japan	1 350 428	80%	270 086	**-3,9%**	603 929	4,1%	1 304 676	**-54%**			
	Portugal	71 681	80%	14 336	**-3,9%**	32 056	4,1%	58 227	**-45%**			
	Slovenia	21 894	80%	4 379	**-3,9%**	9 790	4,1%	19 978	**-51%**			

Clusters	Countries	2010 emissions	Mitigation according to IPCC scenario RCP2.6	2050 emissions following scenario RCP2.6	Average annual mitigation rate 2010-2050	2030 emissions at average annual mitigation rate 2010-2050	Mitigation 2010-2030 in % of 2010	1990 emissions	IPCC mitigation 2030-1990 in % of 1990	IPCC clusters average (%)	COP21 clusters average (%)	Carbon voluntarism
	South Korea	628 839	80%	125 768	**-3,9%**	281 224	4,1%	300 501	**-6%**			
	Spain	354 618	80%	70 924	**-3,9%**	158 589	4,1%	293 343	**-46%**			
	United Kingdom	609 587	80%	121 917	**-3,9%**	272 614	4,1%	777 244	**-65%**			
	United States	6 713 349	80%	1 342 670	**-3,9%**	3 002 300	4,1%	6 136 094	**-51%**			
	Belgium	138 029	80%	27 606	**-3,9%**	61 728	4,1%	137 873	**-55%**			
	Denmark	63 679	80%	12 736	**-3,9%**	28 477	4,1%	72 484	**-61%**			
	Finland	84 372	80%	16 874	**-3,9%**	37 731	4,1%	75 555	**-50%**			
4	France	532 133	80%	106 427	**-3,9%**	237 976	4,1%	554 685	**-57%**	**-55**	**-40**	**High**
	Netherlands	212 418	80%	42 484	**-3,9%**	94 995	4,1%	224 468	**-58%**			
	New Zealand	76 142	80%	15 228	**-3,9%**	34 051	4,1%	65 690	**-48%**			
	Sweden	71 435	80%	14 287	**-3,9%**	31 946	4,1%	77 171	**-59%**			
	Switzerland	57 154	80%	11 431	**-3,9%**	25 559	4,1%	56 394	**-55%**			

Table 9. Comparison between our typology of carbon voluntarisms and the IPCC scenario RCP2.6 taken as a benchmark (IPCC, 2014). Scenario 2.6 is the only one with a 66-100% probability (*likely*) to maintain climate change below 2 degrees. It requires a global GHG mitigation of 41 to 72% by 2050 relatively to 2010. Since IPCC reports are scientific works whose public results are negotiated with States representatives to reach a politically acceptable consensus, it appears reasonable from a climatic point of view to consider the upper limit of the given interval. In order to reach a collective mitigation of roughly 70% by 2050 relatively to 2010, we therefore assumed high income countries' benchmark mitigation is 80% and middle income countries' benchmark mitigation is 55%. We followed the World Bank classification for high income and middle income countries[1]. We then computed the average annual mitigation rates between 2010 (IPCC base year) and 2050 to achieve the benchmark mitigations and then the 2030 emissions if these benchmark average annual mitigation rates are respected. Finally, we computed the mitigation rate by 2030 in terms of 1990 emissions to compare with INDCs submitted for the COP21. Carbon voluntarisms are ranked from *very low* to *high* according to the following rules: *very low* means an increase in GHG emissions by 2030; *low* means a mitigation of less than half the benchmark rate; *average* means a mitigation from half to two thirds of the benchmark rate; *high* means a mitigation from two thirds of the benchmark rate onwards.

[1] http://data.worldbank.org/about/country-and-lending-groups#High_income, accessed June 6, 2016.

References

European Commission (2016) *Factsheet on the Commission's Proposal on Binding Greenhouse Gas Emission Reductions for Member States (2021-2030)*, Factsheet, European Union.

European Commission (n.d.) *EU ETS Handbook*, European Union.

IPCC (2014) *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)].*, Geneva, Switzerland, Intergovernmental Panel on Climate Change.