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EAERE Magazine

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EAERE
European Association of Environmental and Resource Economists

EAERE Magazine serves as an outlet for new research, projects, and other professional news, featuring articles that can contribute to recent policy discussions and developments in the field of environmental and natural resource economics. It is published quarterly in the Winter, Spring, Summer, and Fall. Contributions from the wider EAERE community, especially senior level researchers and practitioners, and EAERE Country Representatives, are included in the magazine.

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Dear EAERE friends and colleagues,

Before I tell you about the new issue of the Magazine, here is an important reminder: EAERE will have its *30th Anniversary* next year and the Council would be very grateful to receive ideas on how we can celebrate this event. Please send your ideas and suggestions to Monica or members of the Council.

After the summer issue, this issue will also be dedicated to the winners of 2019 Awards and give them the opportunity to present their research and research projects.

We start with the winners of the EAERE Award for ERC Grant laureates. **Nadia Ameli**, University College London, and her colleagues ask whether increasing transparency about climate-related risks and policies is enough for institutional investors to move funds from brown to green sectors. **Nikoleta Jones**, University of Cambridge, presents her ERC Starting Grant project that will assess the social impacts of biodiversity conservation policies in Europe.

The winner of the Award for the Best Doctoral Dissertation in Environmental Economics, **Aurélien Saussay,** London School of Economics, writes about the burden of increased gasoline prices for low income households, a topic that has gained attention again since the recent Yellow Vest protests in France.

Aude Pommeret, University Savoie Mont Blanc, and **Katheline Schubert**, Paris School of Economics, are this year's winner of the Award for Outstanding Publication in ERE. They investigate if banking of emission permits is a suitable tool under uncertainty about future emissions targets and irreversibility of abatement technology adoption.

As always, I strongly recommend reading our Juniors-ask-Senior interview, this time with the EAERE Fellow **Frank J. Convery**.

Enjoy reading!

Astrid Dannenberg

Climate finance and disclosure for institutional investors

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Nadia Ameli, *a researcher on finance and policy aspects of climate change and energy issues, is a Principal Research Fellow at UCL Institute for Sustainable Resources, where she led the finance work of two EU Horizon2020 projects: GREEN-WIN and RIPPLES. Together with Prof Daniel Kammen at UC Berkeley, she explored the Property Assessed Clean Energy approach to boost finance to low-carbon projects, which was awarded #1 World Changing Idea of 2009 by Scientific America. She has won an ERC starting grant focusing on the role of climate finance to meet the Paris goals.*

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Hugues Chenet, *PhD in Geophysics, is a researcher in climate change and finance. He is Honorary Senior Research Associate at University College London – Institute for Sustainable Resources and Research Associate at Chair Energy and Prosperity. Hugues is Co-Founder and Non-Executive Director of the 2° Investing Initiative think tank and was 2°ii's Scientific Director (2012-16). He collaborates with the Chaire UNESCO Bernard Maris Économie Sociétés, Rockefeller Foundation Economic Council on Planetary Health, and Japanese Financial Services Agency's research center.*

Achieving the Paris climate goals is a major long-term investment challenge, requiring vast and rapid investment into low-carbon and energy efficient technology, and the alignment of the financial sector with climate goals (Art 2.1c: COP21, decision 1/CP.20). Meeting the current NDC pledges entails on average approximately US$130 billion per year investment in low-carbon technologies and energy efficiency (hereafter collectively referred to as 'low-carbon') between 2016 and 2030, an amount which could double or even treble for pathways consistent with the longer term "well below 2°C" goal of the Paris Agreement (McCollum et al. 2018).

Particular hopes in this regard have been expressed for institutional investors, given their assets under management ($84 trillion in OECD countries in 2017, OECD 2018) and the long timescales of their liabilities, which potentially can match the timescales of climate change. At present

however, less than 1% of global institutional investors' holdings are in low-carbon assets and they accounted for just 0.2% of total climate finance flows in 2016 (Buchner et al., 2017; Oliver et al. 2018). Indeed, institutional funds are far more invested in fossil fuel assets. Around 7% of insurance and pension funds' equity portfolio are exposed to the fossil fuel industry, and that institutional investors' broader exposure to climate-policy-relevant sectors (i.e. fossil-fuel, utilities, energy-intensive, housing, and transport) reach roughly 45% of their portfolio (Battiston et al. 2017).

Challenging the Efficient Market Hypothesis and the role of disclosure

Institutional finance concentrated in carbon-intensive assets also creates concerns about the 'carbon bubble' impact of a sudden transition on capital markets value and indirect impact on financial stability, first discussed by Mark Carney, the Governor of the Bank of England, in 2015 (Carney, 2015). Following Carney's speech, the Financial Stability Board – drawing analogies with the perceived causes of the 2008 financial crisis - argued that a large part of the problem arises from the lack of transparency around these asset holdings, and established the industry-based Task Force on Climate-related Financial Disclosure (TCFD).

The underlying assumption behind these initiatives is that exposing climate-related risks and opportunities to global scrutiny for all the main financial actors, will cause investors i) to move away from carbon-intensive assets to reduce risks and ii) to move into low carbon opportunities to benefit from the enhanced market and value of low-carbon investments. The intellectual basis for believing that transparency can move large volumes of climate finance 'from brown to green' resides in the assumption that markets will respond rationally to information – combining information from climate science and political declarations with concrete information (namely climate-related financial risks) on the holdings of climate-relevant assets, to change investment outlays. More specifically, it puts the onus on *financial transparency,* plus *effective ('demand side') climate policies*, founded in commitments to the Paris goals, a low carbon economy, and the most expected economic signal of carbon pricing.

Whether made explicit or not, this assumes something close to what is formally known as the 'efficient markets hypothesis' (EMH) (Fama, 1970). In assuming that adequate finance will flow given transparency and the right climate policy environment, it implicitly exempts the finance sector itself from the need for other regulatory actions beyond disclosure (Christophers 2017).

The Three Domains framework of economic decision-making

We examine the move of institutional investment into low-carbon assets, but also consider the move out of carbon-intensive assets – i.e. the assumption that disclosure will drive an efficient market response to the 'externality' of climate change. From a policy perspective, we thereby aim to establish overall whether the drive to transparency is likely to be a principal, or even major, contribution to aligning the finance sector with the low carbon transition.

We employ the Three Domains framework (Grubb et al. 2014) of economic decision-making, and use empirical evidence (from a survey of institutional investors), to probe some of the limits of the EMH. The Three Domains framework identifies the presence of complementary domains of economic processes and decision-making; *satisficing*, which reflects the insights of behavioural and organisation economics and is dominated by relatively short-term behaviour based on habits, routines, organisation and network constraints; *optimising*, which lies in neoclassical and welfare economic assumptions, dominated by economically rational actors that seek to maximise their utility within free and efficient markets; and *transforming*, which includes the insights of institutional and evolutionary economics to explore long-term processes of change, including strategic investment in new technologies, structures, infrastructure and institutions. These forces operate simultaneously, across different time horizons and scale of actors. For the survey work, we report insights from 32 semi-structured interviews with experts in North America and Europe, including pension funds, insurers, academics, asset managers and development finance institutions.

Our findings

The institutional low-carbon investment challenge encompasses several barriers and interlinked factors operating simultaneously in all three domains of decision-making and arising from different dimensions: (1) the *climate policy framework*, (2) *finance market structure*, and (3) the *capacities and governance structures* of insurers and pension funds. The (1) Group of barriers, in principle points to the classical role of climate policy, aiming to change the incentive structures arising between high and low carbon investment. The (2) and (3) groups reflect the financial system itself, respectively the impact of existing finance market structures, and the specific characteristics of institutional investors and their governance.

Investors' instrument preferences, their lack of information, experience and track record, and their ambiguity aversion (first domain), combined with weak incentives supporting low-carbon assets (second domain) and lack of appropriate investment channels and long-term climate goals not integrated into macro-economic and financial regulations as well as traditionally institutional investments in high carbon assets (third domain), have been identified as key factors hampering the scale up of institutional low-carbon finance (Table 1).

Domains	**Barriers arising from the policy framework**	**Barriers arising from finance market structures**	**Barriers arising from insurers and pension funds' organisational characteristics**
1st SATISFICING BEHAVIOUR	Ambiguity aversion regarding policy changes	Investors' preferences for tradable financial instruments Lack of clear and reliable data to inform decision-process	Lack of capacity and experience Governance structure incentivising short-term performance
2nd OPTIMIZING UTILITY	Lack of transparency and clarity of the policy framework	Individual rational choices leading to collective irrationality	Regulatory structure incentivising liquidity
3rd TRANSFORMING STRUCTURES/ INSTITUTIONS	Lack of long-term stability and credibility of policy instruments and of the political system Anti-monopoly regulation and trade-off with climate finance support	Lack of appropriate investment channels to scale up institutional finance	Existing institutional investment in carbon-intensive assets

Table 1: Barriers according to the three domains of planetary economics

Therefore, reducing factors that form barriers to low-carbon investment, and incentivising its expansion, requires a range of actions accounting for behavioural practices, pricing frameworks and market design and structural barriers. Policies focusing on the development of standards and engagement, such as data collection and reporting standards, may enable investors to overcome incentives for short-term decision-making. Moreover, the scale up of liquid financial instruments targeting large low-carbon projects, will further increase investors' involvement in the low-carbon economy. Policies based on markets and pricing instruments would influence the profitability of low-carbon investments, and increase their attractiveness to investors. Policies promoting technical and institutional innovation, along with cultural changes, can create the conditions for strategic long-term investment. In particular, strategic deployment of public long-term capital in key phases of the investment channel, such as development finance institutions deploying de-risking instruments

and pooling projects together, with long-term policy signals might allow investors to invest at scale (Table 2).

Our study underlines doubts about the idea that transparency will be sufficient to move large-scale finance out of "brown".

Pillars	Policy solutions
1st Regulations/ standards and engagement	Promotion of clear and reliable data
	Deployment of liquid financial instruments targeting large projects
	Reforms changing managers' incentives schemes along with the way climate risks are assessed
2nd Markets and pricing	Policies incentivising low-carbon investment
	Changes in the financial regulatory system (e.g. Solvency II)
3rd Technical and institutional innovations	Long-term public capital and policies
	Monetary policies and macro prudential regulation
	Reform anti-monopoly regulation
	New and less expensive investment channels

Table 2: Policies according to the three domains of planetary economics

Promoting greater insurer and pension fund low-carbon investment would require simultaneous policies accounting for behavioural practices, pricing frameworks and market design, structural barriers and not only disclosure initiatives as promoted in the TCFD recommendations. More transparency would likely address barriers linked to investors' inexperience and lack of clear and reliable data to inform their decision-making. Transparency might also be relevant to better assess climate-related issues and their potential financial implications, thus preventing potential "carbon bubble" risks and avoiding a repeat of a financial system crashing under the revelation (and re-evaluation) of worthless assets. It is this, perhaps more than anything else, that disclosure is supposed to address. The hope is that fear of carbon bubble risks would drive institutional investors to move money out of these assets and into clean energy investments that would insulate them from this risk. However, transparency will not likely impact the barriers in the other domains, especially the long-term thinking and strategic investment decision.

Full article available:
Ameli N., P. Drummond, S. Bisaro, M. Grubb, H. Chenet (2019) Climate finance and disclosure for institutional investors: why disclosure is not enough. Climatic Change.

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Social impacts of Europe's Protected Areas

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It's been 10 years since the European Union published the Biodiversity Strategy setting as a key goal 'to halt the loss of biodiversity and ecosystem services' among EU countries by 2020 (European Commission, 2011). Despite efforts to meet this goal it is now clear that this will not be achieved (European Parliament, 2015) highlighting the need to improve existing biodiversity conservation tools and develop new ones.

Protected Areas hold a significant place in this discussion as they are the most widely applied tool for biodiversity conservation internationally. According to the International Union for Conservation of Nature (IUCN) Protected areas refer to specific geographical zones where certain restrictions exist for humans in order to protect biodiversity. Today in Europe there are over 100,000 protected areas across 39 countries with a significant overlap of different designations including the NATURA 2000 network (Figure 1), Special Areas of Conservation (SACs) and Special Protection Areas (SPAs), all existing in parallel with seven additional categories of IUCN. Growing calls to protect and restore biodiversity means that the number of protected areas in Europe will need to be increased in the near future while coverage of existing protected areas may be re-considered as climate change will result to the disappearance of certain areas and the emergence of new ones (Nila et al., 2019).

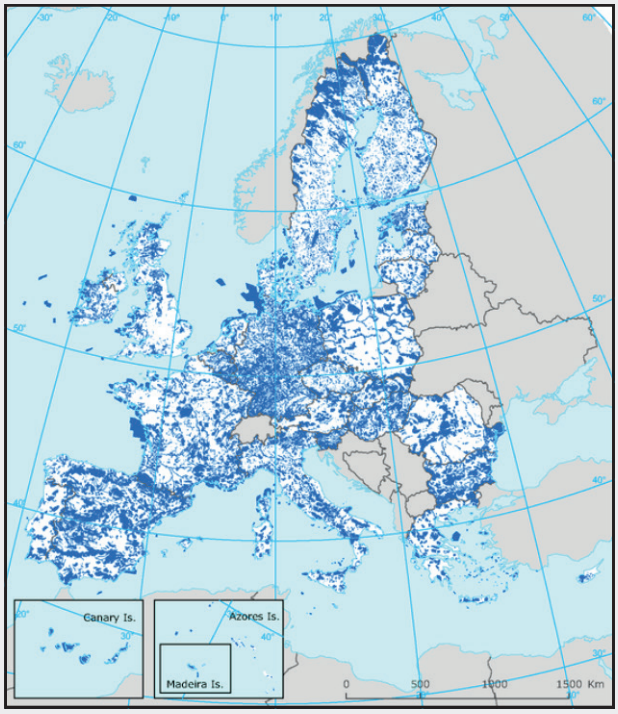

Figure 1. Natural 2000 sites in Europe (source EEA, 2010)

Social impacts of European Protected Areas

Despite the popularity of protected areas amongst policy-makers one should not forget that they are very 'intrusive' for the socio-economic system where they are designated causing significant 'disruption'. The creation of a protected area often means a change in the ecosystem services provided and restrictions for economic activities, such as fishing and logging. Thus they can be a very unpopular tool for local users and visitors. In an effort to capture the benefits and costs of conservation for different users several methodologies have been proposed. These include economic valuation techniques, efficiency evaluation tools for protected areas incorporating social impacts in their measurements and also social impact assessment tools.

In Europe there are very few studies that have focused on assessing social impacts of protected areas (e.g. Rees, 2013, 2014; Jones et al., 2018; Bennett et al., 2019; Hogg et al., 2019). When reviewing the existing literature, these impacts can be divided in four broad categories (Figure 2).

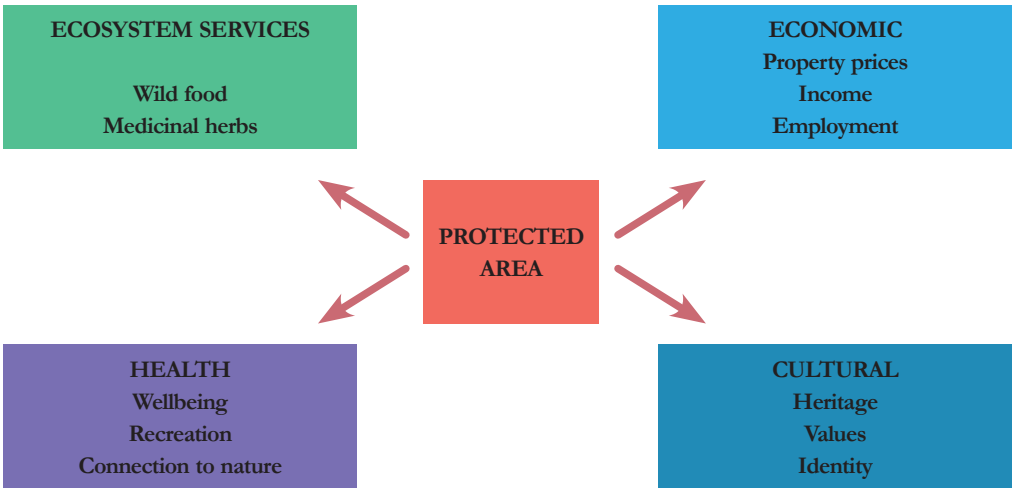

Figure 2. Social impacts of Protected Areas in Europe

A first category refers to *economic aspects*. Income level, especially for individuals whose occupation is directly linked with natural resources, are often significantly influenced by the designation of a protected area. For example, the designation of a Marine Protected Area often means that fishers need to travel further due to fishing restrictions in certain parts of the sea increasing their everyday costs. Furthermore, the designation of a protected area often has an effect on house prices. Some protected areas become exceptionally popular with tourists resulting to a gradual increase of house prices due to the purchase of holiday homes by visitors who wish to visit the area regularly.

A second important category refers to *cultural aspects*. If the planning and designation of a protected area has been completed through a participatory process then often this leads to the protection of cultural values and the local identity. On the other hand, in cases where tourism is significantly increased, this may result to the weakening of social ties and abandonment of traditional professions.

A third category of impacts refers to *health* issues. This includes aspects of wellbeing, which is the most researched impact of protected areas. The impact of ecosystems on human wellbeing was highlighted during the publication of the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005) resulting in numerous studies exploring this beneficial link. Protected Areas are known to have a positive impact on physical and mental health through the increase of recreational activities and facilitating connectedness to nature.

Finally, a Protected Area is closely linked with the *ecosystem services* provided. For example, a 'healthy' ecosystem will provide users of the PA with wild food, fuel and also medicinal herbs.

Directions for future research

From the analysis above, it is clear that protected Areas can have significant impacts, both positive and negative, for local communities. Although this is widely recognised, at the moment there is no commonly accepted methodology in order to assess social impacts of European Protected areas. This is an important gap in the field of environmental policy as after a decade of austerity and neglect of conservation initiatives in Europe (Cortez-Vasquez, 2017) there are now growing calls that European states need to embrace an inter-disciplinary approach in the planning and designation of protected areas. With private protected areas emerging and several rewilding projects established within them it is even more important that socio-economic impacts of conservation initiatives are assessed.

The FIDELIO project (Forecasting Social Impacts of Biodiversity Conservation Policies, ERC Starting Grant, 2019-2024) aims to cover this gap and develop a new framework assessing and explaining social impacts of protected areas by focusing on: a) the variation in perceived social impacts of Protected areas between individuals and how these perceptions are linked with the level of public acceptability for such policies; b) the differences in perceived social impacts taking into consideration the area where they are measured and c) how and why social impacts change through time. The project team will explore these issues through the collection of social data in 19 European Protected Area. The aim is to develop a methodological tool that embraces the diversity of Europe both in terms of cultural, social, economic and ecological characteristics and will allow practitioners to meet biodiversity conservation targets in the future taking into consideration the key principles as underlined by the Sustainable Development Goals.

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Dynamic heterogeneity and household gasoline consumption

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Personal private vehicles accounted for close to 20% of total European and U.S. CO_2 emissions in 2016[1]. These figures make private cars one of the largest sources of GHG emissions in developed economies, rivaled only by the power and industrial sectors. Since the overwhelming majority of these emissions results from the combustion of gasoline, any carbon pricing scheme targeting net carbon neutrality will have to encompass motor fuel at some point in the coming decades. Indeed, the imposition of a Pigouvian tax on gasoline consumption has very often been suggested in the literature as an effective policy tool to reduce its associated emissions (Sterner, 2007; Ross et al., 2017).

However, increasing the price of gasoline – either through carbon taxation, gasoline specific taxation or reduction in fossil fuel subsidies – raises a number of policy issues. In particular, gasoline price increases may affect poorer households disproportionately. Households on the lower end of the income scale dedicate a larger share of their budget to gasoline expenditure than wealthier households, leading to a tax burden inversely proportional to household's income. This effect can make gasoline taxation regressive (Poterba, 1991) – which in turn can raise issues of social acceptability, as the recent Yellow Vest protests have illustrated acutely in France.

Obviously this reasoning only applies to the gross distributional impacts of gasoline taxation. Recycling of the tax receipts can significantly reduce this regressivity of gasoline taxation, or even make it progressive under certain schemes – see Combet (2010) and Berry (2019) for recent discussions.

An extensive literature has examined the distributional consequences of gasoline price increases, with a particular emphasis on identifying the heterogeneity of households' responses to gasoline price variations (Poterba, 1991; Metcalf, 1999; West, 2004; Sterner, 2012; West and Williams, 2012). When this heterogeneity is taken into account, the regressivity of gasoline taxation appears more limited (West, 2004). Further, under the permanent income hypothesis, it may even be close to inexistent (Sterner, 2012).

However, most of these studies have been conducted in the frame of a static model. By construction, this type of model ignores the dynamic nature of gasoline consumption, which involves a double decision: first a discrete choice to invest in a vehicle bundle, then a continuous choice to consume gasoline, given the vehicle(s) available to produce the personal transportation service (Mannering and Winston, 1985). This discrete-continuous process implies an intertemporal dependence in gasoline consumption, which can be a source of additional heterogeneity.

It is well established that household's gasoline price elasticity vary with income (Yatchew and No, 2001; West, 2004; Wadud et al., 2010; Blundell et al., 2012): households on the lower end of the income distribution tend to be more responsive to gasoline prices than their richer counterparts. Yet short-term price responses might not tell the whole story. Households may face rigidities in adapting their gasoline consumption to changing price conditions – rigidities which may also be heterogeneous across the income distribution. For instance, modifying their vehicle bundle through the purchase of a new car may be difficult for liquidity or credit constrained households (Attanasio et al., 2008). More generally, parameters such as the distance between home and workplace or the availability of other transportation modes cannot be changed easily in response to gasoline price variations.

These dynamic dimensions raise a number of policy-relevant research questions, which I seek to address in Saussay (2019): are rigidities to gasoline consumption adaption heterogeneous across households? How does this affect household's long term response to gasoline price increases? How does this potential dynamic heterogeneity affect the regressivity of gasoline price increases?

To this end, I develop a simple dynamic model of household gasoline demand. Following the contributions of Scott (2012) and Filippini et al. (2018), I take inspiration from Becker et al. (1994) to develop a rational habits model of gasoline consumption. This model allows to capture the intertemporal dimension of gasoline demand through a parsimonious functional form linking present consumption to its past and future levels. Importantly, this paucity of data requirements makes it amenable to estimation on long-run household-level panel datasets.

In practice I take advantage of the longest running household panel survey in the world, the Panel Study of Income Dynamics (PSID) in the U.S., which has included gasoline expenditure data biannually since 1999[2]. This yields a large panel of 6,074 U.S. households covering the years 1999 to 2015, a period marked by a high level of gasoline price variance. To complement this household-level data, I construct a localized gasoline price index stratified by state and county density using city and county-level data gathered by the C2ER[3] Cost of Living Index.

Estimation results indicate that households experience rigidities in their gasoline consumption, with relatively strong price elasticities of -0.73 after two years and -0.88 in the long-term in the preferred specification. Importantly, I find evidence of dynamic heterogeneity among households. Rigidities in gasoline consumption are stronger on the bottom half of the income distribution, while conversely the top two income quintiles exhibit stronger forward-looking behavior. This contributes to a large heterogeneity of household responses: I find that households in the lowest income quintile are twice as sensitive to gasoline prices as their counterparts in the top one.

Interestingly, I also find suggestive evidence of interactions between dynamic heterogeneity and the regressivity of gasoline price increases. Due to the greater inertia of their gasoline consumption, households in the bottom two quintiles of the income distribution experience a larger tax burden ratio after periods of falling gasoline prices. This implies that a gasoline tax implemented after a period of lenient prices would be more regressive.

These findings have important policy implications. Beyond a confirmation of the heterogeneity of households' responses to gasoline prices, these results demonstrate the existence and importance of dynamic heterogeneity. Households do not adjust their response at the same rate along the income distribution, which has an effect on the distributional impacts of increases in gasoline price. This makes the case for a reinforcement of compensatory policies targeting households on the lower end of the income distribution.

Endnotes

[1] Sources: European Environmental Agency and U.S. Energy Information Agency

[2] The PSID was conducted annually from 1968 until 1997, and biannually ever since.

[3] Council for Community and Economic Research

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Intertemporal emission permits trading

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In real CO_2 emission permits markets, emissions caps are seldom announced in advance over long horizons. It has long been recognized that this uncertainty about future emissions targets are likely to affect firms' current abatement as well as their current technological choices, especially their investment in clean capital. This should be even more accurate when recognizing the irreversible nature of such technological choices: a utility company will find it too expensive to get rid of a scrubber (and get the cost back) it has installed if emissions caps happen to be less stringent than expected. However, an important characteristic of the emission permits market design provides some flexibility for the firm: the possibility of trading permits intertemporally, that is of banking permits across compliance periods.

The main reason for the banking of allowances is undoubtedly the phase-in aspect of the trading program (see Schennach, 2000) and a crucial characteristics of this phase-in is that next phase standards are not perfectly known. However, the literature focusing on future standards uncertainty is quite recent. The idea of a trading program with potentially more stringent regulations following an initial, less restrictive compliance period can be captured by a two-period model that represents actions taken early on and actions performed in the second period when uncertainty has been resolved. Durand-Lasserve et al. (2010), using an applied general equilibrium model, consider a "hard cap" scenario and a "soft cap" scenario for the end of 2020. They show that a higher probability of a high future cap leads to more abatement and more banking now. Turning to a more theoretical approach, Fischer and Sterner (2011) obtain that future cap uncertainty will affect current abatement and R&D investment depending on the shape of the cumulative marginal abatement cost curve that provides a measure for prudence. R&D, by changing this shape, interacts with prudence. Therefore the latter paper focuses on a Jensen effect of uncertainty but does not account for the joined effect of technological irreversibility and future cap uncertainty. However, such an effect of irreversibility should be worth considering since it could potentially be mitigated with the flexibility provided by intertemporal permit trading. This is the objective of our paper.

In the paper, we consider intertemporal emission trading, i.e. banking of allow-

ances, under future standards uncertainty and technological irreversibility. We explore the consequences of uncertainty and irreversibility on investment in clean capital and current and future abatement. The objective is first to analyze the effect of uncertainty on clean capital investment in the presence of pollution permits markets and banking. Second, it is to appraise whether under uncertainty, banking provides an incentive for investing in clean capital. Based on this appraisal, we are able to provide policy recommendations to avoid the usual adverse effect of uncertainty on irreversible technological choices.

We explore the problem of minimizing the cost of intertemporal emission control by heterogeneous firms in the presence of an uncertain future cap and emission permits that are tradable across firms and through time. A firm can invest in clean capital (an improved pollution abatement technology) to reduce its abatement cost. Clean capital is irreversible and irreversibility can be binding i.e. without this constraint the firm would choose to disinvest, or not i.e. the firm would freely choose to make positive investment.

We first obtain some results in a two-period model absent any uncertainty. Allowing firms to bank permits across the two periods may make them invest less in clean capital during the first period: while investment in clean capital is always positive when no banking possibilities exist (provided of course that the future cap is lower than BAU emissions), it is positive only if the interest rate is relatively low and the future cap stringent enough when banking is possible.

We also consider the effect of the irreversibility of the investment in clean capital absent uncertainty. We show that banking, abatement and investment in clean capital at period 1 are smaller when irreversibility is accounted for and binding, that is when it would be optimal for firms to invest a lot in first period and disinvest in second period were their investment in clean capital reversible. This result is consistent with the intuition on the effect of irreversibility that adds a constraints on firms. Regarding the effect of irreversibility on banking, we show that positive banking and investment in clean capital at first period are complements when irreversibility is not binding, whereas they are substitutes when irreversibility is binding.

We now turn to the optimal behavior of the firms when the environmental policy is uncertain. Uncertainty is captured within a two-period model. Only the current period cap is known by the firms. When irreversibility does not play any role (i.e. it is not binding), uncertainty may lead to more investment in clean capital and more abatement, depending on the relative curvatures of the abatement cost function with respect to abatement and clean capital. In addition, positive banking and investment in clean capital at first period are complements. When irreversibility is binding, uncertainty may still lead to more investment, but the condition under which this is the case differs (it is however still related to the curvature of the marginal abatement cots). Importantly, whether positive banking and investment in clean capital are substitutes or complements depends on whether irreversibility is binding: if it is binding regardless of the second period cap they are substitutes, while if irreversibility is only binding for a high cap they are complements. We obtain therefore that banking may be a means to take advantage of uncertainty and irreversibility in the most plausible case where irreversibility is only binding when the cap is increased because it breaks the substitutability between banking and earlier investment in clean capital. Note that on the contrary, Phaneuf and Requate (2002) obtain that banking and investment in clean capital are always substitutes since they do not allow for any investment after the resolution of uncertainty.

We obtain therefore that if banking is positive and marginal abatement costs are sufficiently convex, there will be more abatement and clean technology under uncertainty than there would be under certainty and no banking. Accounting for the irreversibility of investment in technology, additional parameters that are crucial for the effect of uncertainty and of banking are those describing uncertainty and the interest rate. It is then possi-

ble to find values for these parameters such that uncertainty (and irreversibility) induces more abatement and clean investment than when uncertainty is ignored. In addition, in the most plausible case where irreversibility is only binding when the cap is increased, allowing for positive banking induces more investment.

To conclude, we show that banking can be an effective means to take advantage of uncertainty and irreversibility on the adoption of improved abatement technology. Banking can also increase abatement in the first period, meaning that lower pollution damages would be generated when considering the discounted sum over the two periods of each period's damage. But for all these results, a necessary condition for a positive effect of banking on clean capital investment is the convexity of the marginal abatement costs. Therefore, we claim for a precise information on the shape of these marginal abatement costs that would be a requirement prior any policy recommendation concerning the banking of allowances could be made.

We acknowledge that we impose a large number of simplifying assumptions in our model: firms' production decisions are ignored, micro abatement costs are such that they allow for aggregation. Such a simple framework cannot be used to derive general conclusions but is enough to conclude that uncertainty and irreversibility do not always generate less technology adoption and less abatement. An extension of this work would be to endogeneize the regulator's optimal second period cap. It would make sense that the second period cap depends on the level at which firms invested in first period. This would give rise to an interesting hold-up problem since firms would foresee the relationship between first period investment and second period cap.

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Juniors-ask-Senior

Interview with Frank J. Convery

Frank J. Convery *has a PhD in resource economics from the State University of New York. He served as: Assistant and then Associate Professor of resource economics at Duke University, Research Professor at the Economic and Social Research Institute, Heritage Trust Professor at University College, Dublin and Chief Economist at the Environmental Defense Fund. He was visiting professor at the World Bank, Kyoto University and MIT. He is former President and current Fellow of the European Association of Environmental and Resource Economists. He is a member of Ireland's Climate Change Advisory Council. His career has been devoted to finding ways that work to correct for the failure of markets untrammelled to protect the environment. He led the research network that informed the shaping of what became the European Union Emissions Trading Scheme (EU ETS), which put a price on emissions emerging from the power sector and heavy industry in Europe. He served as a member of the Irish Commission on Taxation which in 2009 recommended the introduction of a carbon tax. The government acted on this recommendation and introduced the tax in 2010. He has authored or co-authored several books and over 100 articles.*

1. What is the most important advice you would give to young researchers starting a career in environmental and resource economics?

I would stress the importance of listening to experienced researchers, what they understand it takes to be a successful economist and their methodological style. You can learn a lot by listening to more experienced researchers, and I have learnt that people are generally very keen to help if you ask them. However, you need to reach out to them, which I honestly wish I had done more in my early years. As for the topic to choose, it needs to be something you feel concerned about and attached to. This will help you to get through when you hit a wall, which sooner or later happens to all of us. A strong motivation is key in this sense.

2. How do you get the ideas for your research?

I work on the policy practitioner side of the profession; therefore, I tend to keep an eye out for opportunities when there are problems which are damaging the public interest, and then I try to think of what kind of research could help policy makers take the right decisions. Just to give you an example, in Ireland we had a huge problem of plastic bags litter. Therefore, we started to do some research on the plastic bags levy to see if it was feasible to tax them. We came out with a model which the Irish government then successfully implemented. This is a small example but gives you the idea of the process leading to new research opportunities.

3. Which research areas or questions in environmental and resource economics do you personally think deserve more attention?

The motto of the organization I worked with from 2014-2018– the Environmental Defense Fund (EDF) - is "Finding the ways that work". I think it is a very precise way of defining what should be the purpose of more of our work. Indeed, I feel that much of our current research in environmental economics is missing this interface between theory and practice which allows concrete decisions to be carried

out effectively. It is harder to model, but I would encourage colleagues to think about the practical implications of their work, in order to provide solutions that can be reflected in an effective and positive change in the course of action.

4. Do you think environmental economists could have done better at advising policy makers to address the climate change problem?

I think we have obtained some amazing achievements. For example, Europe adopted economic advice almost from the beginning of its policy shaping, back in 1992 with the decision to adopt a carbon tax, which was our recommendation at that time. The measure failed due to the politics attached to it, but then we introduced the Emissions Trading System, which is also a market-based instrument; many other jurisdictions have also used the results of our theory and empirical work to shape their policies.

However, I suppose that a gap we didn't fill very well was helping the policy system to find ways to make these approaches acceptable to people: many measures are currently not very well seen by the general public. Another research area where we could improve is low cost carbon innovation: it would be interesting to look more into how to create innovative technology able to change the outcomes of our actions – the carbon prices we have managed to implement are generally not sufficiently high or pervasive to do so. Currently, I am looking at the meat substitute industry and how it emerged in the market: at this time, an extraordinary volume of money is being driven towards this sector; it may well prove to be a key source of greenhouse gas emissions reduction in animal farming.

5. Do you offset the carbon emissions from your flights? Why (not)?

I almost always do, and I think it is important. However, sometimes the interfaces of some airlines' websites make it a quite complicated process for people to offset their emissions. Some others in turn are very easy, with a simple box to tick. A simple step which would improve outcome would be to dramatically reduce the transactions costs of doing so. I think it could be useful to require all airlines to make this option possible and easy to find. This will be a new focus of my advocacy!

6. Young freshman students often loathe the idea of comparing costs and benefits when it comes to environmental protection and regulation. How do you convince them that these things are important?

I think I would simply suggest them to reflect upon the fact that if you choose a less expensive course of action, that leaves you more money to do other things. On the contrary, if you undertake an action which is very expensive, you are left with little money for a second one. What is used for A cannot be used for B, therefore we need to be very careful when we choose.

7. What was the funniest experience you had when you gave a lecture or a talk at a conference?

I tried to convince some fishermen to adopt an economic model called "Catch shares (ITQs)", with which they would get fishing quotas, the sum of which did not exceed the allowable catch; these could then be traded. They regarded me with huge hostility and as I went on they became extremely agitated. The result was that my host for the meeting had to help me escape. I learned a lot from this experience: I realized that the way I had tried to sell the idea was just ridiculous… Now I remember this episode with amusement, even though it was dramatic. Thirty years later, I learned from EDF how I could have done it much more effectively.

8. Which career / job did you have in mind when you finished high school?

I started out with a degree in Forestry. However, I soon discovered my sense of direction leaves a lot to be desired, and thus going into a forest was a bad idea because

I would probably not be able get out of it again. But there were some economics courses in my academic curriculum, and I took an increasing interest in them, and this led me to do a PhD in Forestry Economics on the US; we can say that I evolved towards economics from my experience in forestry.

9. If you decided about your career today with hindsight, would you choose the same route?

Yes. I was lucky, I think I fell into a space I really love. Honestly, there is nothing I would change.

10. Which book are you reading at the moment?

For us Europeans, Greece is where the renaissance began. Currently I am reading a book called "Mythos: The Greek Myths Retold" by Steven Fry, which is essentially a guide to Greek mythology. I love wider literature and during my education years I never had the chance to learn systematically about Greek mythology: it's a gap in my education that I would like to fill now.

11. If you could select a person (alive or deceased) to have dinner with, who would that be?

I think it would be Voltaire. I love his practical courage in advancing clear thinking and evidence-based analysis with honour and wisdom: he managed to find a balance that allowed him to successfully promote his work and his beliefs, to survive in spite of the strict censorship laws of the time. Also, he had a very good sense of humour.

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