Research Statement

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My primary research fields are macroeconomics, environmental economics, and international trade. My research focuses on designing optimal economic policies to mitigate the adverse consequences of climate change, business cycles, and systemic disruptions, particularly in energy markets or supply chains. With this aim, I use theoretical and quantitative modeling to understand the implications of such shocks on inequalities across countries, households, and firms.

The first line of my research is concentrated on the fundamental principles behind the optimal carbon policy to fight climate change, accounting for inequality across countries. Indeed, taxation of carbon and fossil fuels has strong redistributive effects across countries. First, it affects rich and poor countries differently as emerging economies face challenges in reducing fossil fuels necessary for their economic development. Second, regions are differentially affected by global warming. Third, phasing out fossil fuels has substantial impacts on energy markets, affecting the energy rent of oil and gas producers, while energy taxation distorts energy demand. Lastly, imposing a carbon tax in a country reallocates economic activity and emissions toward other countries through the "carbon leakage" effect and, therefore, reshapes the patterns of trade internationally.

In my paper, **Inequality, Climate Change, and Optimal Climate Policy**, I ask whether the optimal carbon policy should account for all these redistributive effects. In the Pigouvian benchmark, the optimal carbon price is simply equal to the Social Cost of Carbon – a measure summarizing the cost of emitting one additional ton of CO_2 due to future costs of climate change – without regard for distributional impacts. However, I claim that this result – prevalent in the Representative Agent version of Integrated Assessment Models (IAM), for example, Nordhaus (2017) and Golosov et al. (2014) – may fail with heterogeneous countries. In particular, the level of the optimal carbon tax depends crucially on the availability of redistribution instruments – e.g. lump-sum transfers. I study this question in an IAM with heterogeneity. After characterizing the Social Cost of Carbon (SCC), I derive formulas for the Second-Best fossil-fuel tax when cross-countries transfers are absent. I show that a uniform carbon tax should account for fossil-fuel supply redistributions, demand distortions, and trade general equilibrium effects and that the level is reduced twofold in the presence of inequality – \$150 per ton of CO_2 instead of above \$250 when transfers are available. If country-specific carbon taxes are available, the distribution of carbon prices is proportionally related to income: poor and hot countries should pay lower energy taxes than rich and cold countries. These qualitative results are general, and I propose a dynamic quantitative model to provide recommendations for optimal carbon taxation.

However, a global carbon policy is still subject to the free-riding problem of climate policy. Indeed, behind the lack of global cooperation on climate action is the presence of free riding: the benefits of fighting climate change are global, while the costs of reducing emissions are local. Individual countries have incentives to free ride on the rest of the world without implementing costly carbon abatement themselves. Moreover, this free-riding problem is exacerbated due to the strong redistributive effects of carbon policy, as mentioned above. Multilateral climate agreements have been the traditional answer to address climate inaction, without achieving decisive binding policies. More recently, trade policy has been the focus of policy discussions, as it can incentivize other countries to reduce emissions. Nordhaus (2015) proposes the idea of a "climate club", a voluntary agreement where members implement common carbon taxation and retaliatory tariffs on countries that do not participate in the club. In this context, trade sanctions are necessary to foster participation in the club and reduce free-riding incentives.

In my ***Job Market Paper***, **The Optimal Design of Climate Agreements**, I study how to design the optimal climate club. I study the optimal level of carbon tax when accounting for free-riding incentives, as well as the optimal tariffs on non-members, and the choice of countries composing the climate agreement. This reveals a tradeoff between an intensive margin – a club with few countries and large individual emission reductions – and an extensive margin – accommodating more countries at the cost of lowering the carbon tax. In an IAM with heterogeneity and international trade, I study the optimal agreement design problem when countries make strategic decisions to join or leave the club, mirroring an optimal taxation problem together with a choice of countries, or combinatorial discrete choice, for the coalition. I find that the optimal climate club consists of all countries except Russia, a \$100 tax per ton of CO_2 within the club, and a 50% tariff on goods from non-members. As a result, the presence of free-riding incentives requires lowering the carbon tax from \$150 to \$100 to foster participation and reduce global emissions. However, if one wished to include Russia, which is cold, a large fossil fuel exporter, and relatively closed to trade, we would need to lower the carbon tax so much that it would not be enough to curb global emissions. Such an agreement allows for an increase in welfare by 5% and a reduction of emissions by 33%, despite free-riding incentives. In several extensions, I study additional policy instruments, such as transfers or fossil-fuel-specific tariffs, as well as strategic retaliation considerations and how they affect the stability and design of the climate agreement.

In future projects, I would like to extend this line of research in two different directions. First, future climate damages are largely uncertain, both through the climate system and the existence of tipping points, as well as our lack of knowledge of the future economic impacts of climate change. Moreover, the impact of this uncertainty is also heterogeneous, and this interacts with differences in incomes and temperatures across countries. In an earlier work linked to the two previous projects, **The Distributional Consequences of Climate Uncertainty**, I showed analytically that the SCC and the optimal carbon tax depend on the covariance of ex-ante heterogeneity and ex-post heterogeneity (due to risk). Solving such models with non-linear dynamics, path-dependence, heterogeneity, and aggregate risk requires using novel methods for solving those climate-economy models globally – methods that I developed borrowing mathematical tools from the "Probabilistic Approach to Mean-Field Games", e.g. Carmona et al. (2018). Moreover, in these environments, carbon taxation and climate agreements provide an insurance mechanism against those climate risks – which can be substantial given the curvature of utility and damage functions.

Second, another question about the interaction between inequality and climate change relates to the ***fairness of climate policy***. This moral aspect is often absent from economic models but is often discussed in policy circles. Indeed, most of our forward-looking climate policy frameworks are silent on the question of whether developed economies, which have contributed to the largest part of cumulative greenhouse gas emissions, should pay a higher carbon tax than emerging and low-income countries. In this future project, I propose a micro-foundation of such an argument, which relates to the optimal level of economic reparation. Indeed, if the Social Planner starts its optimal plan in pre-industrial times instead of today, and if it is "constrained" by past climate inaction, the optimal carbon policy in the future accounts for past emissions – acting with a backward-looking motive. It would compensate optimally the countries that have a smaller responsibility for the climate problem and did not benefit from past fossil-fuel consumption for their economic development. This logic could not only be applied to climate and carbon budgets but also to other topics, such as resource appropriation across countries and optimal reparation.

A second line of my research focuses on the impact of business cycles across income and wealth distribution. In **A Perturbational Approach for Approximating Heterogeneous Agents Models**, joint with A. Bhandari, D. Evans, and M. Golosov, we study how to simulate models with household heterogeneity when macroeconomic uncertainty is important. We show how to characterize analytically these models with linear systems of equations and approximate locally the equilibria despite the complex interaction between aggregate risk, agents' decisions and the distribution evolution. Taking a second-order perturbation of the equilibrium allows us to study the welfare effect of uncertainty, stabilization policies, time-varying risk, and endogenous household portfolio formation. This method is extremely fast and efficient and is being implemented by the Dynare team to provide a user-friendly approach for simulating HA models.

Similarly, in **When is aggregation enough? Aggregation and Projection with the Master Equation**, I take an alternative approach to the previous perturbation method, which is local, and propose a global method inspired by Krusell and Smith (1998). I solve these models with agent heterogeneity and aggregate risk using the Master Equation – developed in the Mean Field Games literature, e.g. Cardaliaguet et al. (2019). Using projection, I bypass the bounded rationality assumption: households still consider a few moments of the distribution when making expectations, but their dynamics are now fully non-linear and consistent with equilibrium outcomes. I obtain a *global* characterization of the agents' value and aggregate dynamics, and I plan to study richer models with portfolio choice where perturbation methods are limited. This approach is related to my earlier work **The Wealth Distribution over the Business Cycle, A Mean-Field Game with Common Noise**, which also leverages mathematical and continuous-time methods for economic modeling.

In **Non-Keynesian stabilizers and wage-inflation spirals**, joint with F. Le Grand and X. Ragot, we study how the joint optimal fiscal-monetary policy should be conducted in the presence of nominal frictions on both prices and wages, implying wage-inflation dynamics. Depending on the availability of fiscal tools like labor tax and wage subsidy, the optimal policy searches at closing the labor wedge and stabilizing the price dynamics. This framework gives a new role for public debt and these fiscal policy tools have a non-Keynesian motive through the interaction between heterogeneity and wage-inflation spirals.

Finally, in a third line of my research agenda, I am interested in understanding the spillover of economic shocks on the macroeconomy and across sectors and firms. In **Supply Chain Uncertainty and Diversification**, joint with I. Cuevas and G. Gonzalez, we study how supply chain disruption uncertainty affects firms and how they adapt by diversifying foreign suppliers, re-shoring, or selecting suppliers based on cost and risk considerations. We study this question in a multi-country sourcing model inspired by Antras et al. (2017) with risky supply-chain trade shocks. Uncertainty introduces both a positive option value due to supplier diversification and a negative hedging motive due to aggregate risk, yielding ambiguous predictions on firms' sourcing decisions. We leverage firm-level data from Chile to estimate supply chain risk and we assess the impact of the surge in risk following the Covid-19 pandemic.

In **Energy shocks and aggregate fluctuations**, I study how important shocks to energy markets are for economic fluctuations. I analyze the contribution of energy demand and supply shocks – oil shocks, for example – for business cycle fluctuations using an RBC model that features a high degree of complementarity and non-linearity in production. I show that the expansion of energy supply was significant for output growth in the post-WWII period, and its decline explains part of the slowdown since the second oil shock. I estimate that energy shocks explain between 20 and 30% of output volatility.

To conclude, my research agenda is driven toward policy-oriented topics related to the implications of inequalities across countries, firms, or households in the face of climate change, the energy transition, risk and uncertainty, and business cycles. I believe the economic literature has now acquired the appropriate tools to study them with theoretical and empirical tools to provide accurate recommendations for policymakers.

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