KCL & ETERON Institute Grant *Reclaiming Europe's Industrial Policy Through Just Taxation and Innovation* — Research Proposal

Inequality and Fiscal Policy in a Spatially Uneven Green Industrial Transition: a New-Keynesian Model with UK Data

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Abstract

The green industrial transition, understood as broad-based substitution of "dirty" energy inputs with "clean" ones in industrial production and household nondurable consumption, is a central component of Eurozone and UK short-to-medium term industrial and innovation policy plans as laid out in the Draghi Report and UK Invest 2035. Assessing its consequences for short and medium term macroeconomic dynamics is therefore an urgent exercise, calling for the development of models to examine the macroeconomic transmission of green industrial policy in a short-to-medium run perspective and to serve as quantitative policy labs. This proposal takes stock of the nascent DSGE literature on such transmission, and sets forth the analysis of the pass through from (alternative) green industrial policy tools to distributional and economic inequality outcomes, alongside a more traditional emphasis on monetary and real aggregates, as a key current research gap. Then, it outlines the main aspects of the proposed modelling strategy, including the development of the DSGE model and two routes to estimating it against UK data, and proposed policy analysis applications.

1. Background and Problem Statement [1]

The achievement of the *Green Industrial Transition* (GIT) is regarded by policymakers and as a key component to the delivery of a successful industrial policy in the EU and UK, as respectively laid out in the frameworks provided by the Draghi report (2024) and the UK's Invest 2035 plan. To a large extent, delivering GIT involves the substitution of current fossil fuel sourced energy ("dirty energy") for renewables or green-sourced energy ("clean energy") both as inputs to industrial production and as nondurable components of households consumption.[2]

While delivering such substitution in private sector energy inputs has been consolidated as a matter of urgency in the EU block and UK's industrial and innovation policy plans in the short-to-medium term, two interrelated economic and policy-relevant aspects of implementing GIT remain much less clear. First is an assessment of alternative policy intervention options for facilitating the transition and their interaction with naturally distortionary fiscal and monetary policy tools — in other words, the macroeconomic transmission of green industrial policy. Second is an assessment of the implications of such transmission for welfare-distributional and inequality implications, and how this varies across

[1] We are grateful to Matija Lozej (Central Bank of Ireland) for the comments and feedback provided on the research framing and proposed modelling approach.

[2] Naturally, this characterisation of GIT abstracts from complementary issues, chiefly the limitations of emissions from the industrial production and distribution process itself in some industries (e.g. the concrete one).

alternative feasible policy measures to implement it. Contrary to a host of earlier work in Integrated Assessment Modelling (IAM) and Computable General Equilibrium (CGE) generally geared toward long-run or static analyses, in the recent years a body of work in the macroeconomics and monetary-fiscal policy literature has developed that engages with the above questions from the requisite short and medium run perspective, through workhorse micro-founded DSGE models functioning as policy labs (Coenen et al., 2024; Del Negro, 2023; Priftis and Schoenle, 2023; Ferrari and Landi, 2018; Annicchiarico and Di Dio, 2015; Angelopoulos et al., 2010).

Despite contributing to the nascent analysis of the macroeconomic transmission of green industrial policy, such recent research has however been fundamentally concerned with the transmission to Eurozone and UK inflationary dynamics and appropriate calibrated monetary-fiscal responses. A critical departure point from the above literature on the construction of the DSGE driven policy labs is recent macro-econometric evidence from the UK indeed points to significant distributional non-neutralities of green industrial policy for inequality across households, particularly through labour market effects and differential penalisation of sectors through green industrial policy, and highlights potential roles to play for redistributive fiscal policy (Känzig, 2021). However, channels able to micro-found such results, both generally in this literature and specifically in UK case, remain fundamentally unexplored in the above DSGE modelling exercises. As is more generally the case within the industrial policy and innovation modelling literature (Roeger, Varga, and Veld, 2022), of which energy innovation and transition is an instance, a sharper focus on distributional and inequality, as such, stands out as a complementary focus critical to an assessment of the Draghi and UK Invest 2035 industrial policy blueprints, via a fair taxation and distribution lens at the heart of KCL-ETERON Institute joint project. Addressing such critical gap and to micro-found similar empirical findings to, the project aims to develop, estimate, and deploy to policy applications a DSGE addressing two questions:

I. First, the macroeconomic transmission of green industrial policy: how alternative green industrial policy tools affect structural economic inequality along the transition, and with what implications for redistributive fiscal policy.
II. Second, how the deployment of similar tools influences heterogeneity in the macroeconomic transmission of aggregate shocks across household types once the transition is achieved.

In terms of the substantive modelling contribution, the project proposes to depart from the existing DSGE modelling literature in two key respects, centred around the role of spatial inequality — particularly between a stylised "core" and a "periphery" region of the domestic economy — under the plausible assumption of immobile firms and relatively immobile labour in the short run. First, abandoning the assumption of a uniform green transition on the part of an aggregate firm, and instead allowing for endogenous "greener" and "browner" firms (and households) to specialise their energy input demands in clean or dirty energy. Connecting this to spatial inequality is a plausible assumption, particularly in the case of the UK, of transaction costs associated to importing clean energy services from the core, so that firms in the periphery end up with "browner" specialisations.

This modelling approach as such aims to match spatial unevenness in the distribution of green and brown firms and, critically for connecting it to structural economic inequality on the households side, differential exposures of jobs (worked hours) in the periphery and core to green industrial policies. Second, in line with frontier approaches, enabling such endogenous structural inequalities in economic opportunity across space to interact with financial frictions, particularly liquidity constraints, on the household side and their heterogeneous distribution across "core" and "periphery" known from the TANK literature to be critical to successfully replicating empirical patterns in income and consumption inequalities. The expected output is thus a model that novelly incorporates structural inequality as an outcome affected by green industrial policy and in turn driving the latter's transmission to aggregate dynamics. Stemming from spatial heterogeneity in exposure to the green industrial transition, the output is a model that (a) can micro found empirical findings on the distributional non-neutralities of green industrial policy and (b) that, once estimated with UK data, can serve as a lab for simulation-based assessments of the macroeconomic transmission of alternative green industrial policy tools to inequalities and via inequalities to aggregates, to address the research questions set out above. In particular, three alternative industrial policy and innovation tools are considered, together with their interplay with conventional domestic fiscal policy and redistributive tools: (1) carbon pricing, (2) clean energy subsidies, and — a novel one with respect to the literature but taking on board the Draghi report — (3) directed financial investment in clean energy suppliers.

2. Background Literature

The centrality of the green industrial transition to both the Draghi Report and the Invest 2035 strategy has stimulated considerable interest in the macroeconomic transmission of policies aimed at facilitating the transition. As pointed out, the recent years have been marked by a small number of contributions in quantitative macroeconomics and monetary economics that interface green industrial policy with macroeconomic transmission, through the extension of workhorse DSGE and particularly New-Keynesian models. Left out of this review are older contributions in the Integrated Assessment Modelling strand (e.g. DICE, RICE) that while seminal in the field of climate macroeconomics, are less relevant in terms of modelling setup and applicability to the short-to-medium run of interest to macroeconomic transmission (Nordhaus 2017, 2008).

While these more recent studies provide important contributions, they are limited in their ability of the developed DSGE framework to shed light on distributional and inequality implications, both as a target of analysis in its own right and as a further, neglected channel of transmission from green industrial policy to aggregate dynamics. Ferrari and Nispi Landi (2022) augment the two-period NK model by Benigno (2015) and then extend the analysis to a fully-fledge medium scale DSGE model to investigate the impact of green industrial policy, through a prototypical carbon tax, for inflationary dynamics, finding that whether the green transition generates deflation or inflation importantly hinges on the credibility of the government's industrial transition plan.

Motivated by a similar concern with inflationary dynamics and inflation-management and output-stabilisation tradeoffs along the green industrial transition but though a richer quantitative setting, Del Negro et al (2023) extend the NK model to include sectoral heterogeneity, similar to the our proposed modelling approach, between "green[er]" and "dirt[ier]" sectors and investigate the implications for inflation of excises on the dirty sectors versus subsidies to clean ones in the presence of structural differences in the slopes of the sectoral Phillips Curves. Their key finding is that the desirability of the tax approach as opposed to the subsidy as tools for delivering the green transition crucially hinges on the relative flexibility of nominal prices between green and dirty sectors. While, similarly to the one by Ferrari and Nispi Landi (2022), the analysis by Del Negro et al (2023) generally abstains from engaging with the distributional and inequality side, it dialogues with proposed project due to the similarly emphasised overlap between sectoral heterogeneity in terms of energy inputs and heterogeneity in structural features driving macroeconomic transmission. In their case, the latter are relative nominal price flexibilities (or inversely, sectoral Calvo rigidity parametres), while in the proposed spatially unequal model they are local labour markets (employment and wages) and their interaction with differential degrees of financial frictions across the core and periphery. Further, while they take the green-ness of a sector as exogenously determined, the proposed model instead makes it an endogenous equilibrium outcome depending on the transaction costs and prices of clean energy relative to dirty one, capturing missing general equilibrium effects when firms freely specialise in energy inputs.

A recent contribution by Coenen et al. (2024), on which the modelling proposed here builds, extend the New-Keynesian framework in the ECB's NAWM to include disaggregated energy inputs, differentiating between clean and dirty energy, and accordingly study the impact of permanent hikes in carbon taxes on inflationary and aggregate output dynamics under alternative monetary policy rules. Interestingly, they also shed light on distributional non-neutralities of the policy, and hence the potential role for redistributive programmes, for consumption inequalities across households. However, the analysis of distributive effects in their model is predominantly driven by generic financial market frictions and hand-to-mouthness, implying constrained households with larger marginal propensity to consume adjust their consumption more in response to transition-induced permanent income shocks. Hence, the model is moot on distributive effects through green industrial policy induced changes on the aggregate supply side and particularly differential outcomes in the labour markets in which household sell labour service. The model we propose, by contrast, places the interaction of standard financial frictions and differential labour market outcomes across space at the centre of the analysis. Similar observations apply to the closely related paper by Carton et al. (2022), who propose a global rather than EU-area model and a similar disaggregation of energy production, converging on similar results on aggregates, and to Bartocci et al. (2022).

In general, there are two main take-homes from the available literature. The first one is that in general extant studies have been particularly concerned with the macroeconomic transmission of green industrial transition, through alternative implementable policy tools, limitedly to inflationary dynamics (in the EU and UK, with both Bank of England and the ECB characterised by single mandates) and aggregate output (in the US, where the Fed has a dual price stability and output stabilisation mandate). A consideration of inequality and distributional implications of the transition is either absent, or limited to a by-product of the standard (TA)NK setup with liquidity constrained or hand-to-mouth households. This is not only important as distributional and inequality outcomes are important in themselves for assessing the costs of the green industrial transition and, if at all, the role of redistributive fiscal policy. It is also important as a further amplification channel for transitional dynamics in the aggregates typically of interest to monetary and fiscal authorities — inflation and output dynamics (Coenen et al., 2024). As such, the proposed contribution would be one of the first studies by integrating standard micrcofoundations for inequalities in the form of liquidity constraints and hand-to-mouthness with supply-side un-equalising implications of green industrial policy via the labour markets in which differentially constrained households operate. The micro-foundation of such overlap through a spatially unequal exposure to the green transition, resulting from the combination of specialisations of firms inputs in the face of transaction costs and relatively low-mobility labour, is also, to the best of my knowledge, a fully novel angle on the transmission of green industrial policy. Scalability to political economy issues, such as spatial cleavages in support or opposition for green transition policies, is a natural application of the work in future extensions or spin-offs.

3. Planned DSGE Modelling

The central output of the paper is the development, estimation with UK data, and subsequent application to simulation-based assessment of alternative green industrial policy tools for distributional dynamics and, through them, aggregate ones. While the development of the modelling methodology consists of the bulk of the research to be carried out, and can at this stage only consist of preliminary directions, a number of planned elements in the model and estimation strategies can be highlighted.

3.1 Model Development and Estimation

The main ingredients of the proposed augmented NK model have been set out in the introduction and literature review.

At the core of the proposed model of inequality with a spatially uneven industrial transition lies the interaction between inequality-enhancing forces on the supply-sides of the core and periphery regions, elicited by different types of green industrial policy, and financial frictions or liquidity constraints on households assets demand in the respective local labour markets. Particularly, it is envisioned that underlying the former will be two joint aspects: first, the endogenous specialisation of firms located in the core and periphery in different mixes of clean and dirty energy inputs (greener or browner) depending on transaction costs associated to substituting brown energy (the default option) for clean energy. Ideally, such transaction costs will be linked to government investment in infrastructure, opening the way to a fourth dimension of green industrial policy in addition to the listed ones. Second, the relatively low-mobility labour assumption, which implies households in the core and periphery will end up (as an outcome to be targeted through the calibration) supplying labour to respectively greener and browner firms. With such a set-up, the model aims to generate an environment in which households in the periphery bear larger costs from the implementation of green industrial policies than their counterparts in the core, and as such allows for examining how different such policies endogenously generate income and labour market inequalities in space. Second, this supply-side endogenous inequality (in labour incomes) will interact with heterogenous liquidity constraints in generating spatialised wealth and consumption inequalities. Because the model is cast in general equilibrium, the two dimensions interact. Underlying this is, finally, a disaggregated energy sector on the lines of Coenen et al. (2024) that differentiates between brown and green energy providers, assuming the latter are all located in the core. Contrary to Coenen et al. (2024), a further step is allowing for energy-firm specific capital accumulation and share ownership, opening the way to studying the role of directed financial investment and asset purchases as an alternative green industrial policy tool.

With such set up, once the model is estimated with UK data (see below), the analysis proceeds by examining transitional dynamics in inequality and aggregates associated to three "permanent shock" type policy measures (1) carbon pricing, (2) clean energy subsidies, and — a novel one with respect to the literature but taking on board the Draghi report — (3) directed financial investment in clean energy suppliers. The solution for such transitional dynamics is, as standard, in the *sequence space* with a perfect foresight assumption (albeit this can be relaxed later). Complementarily, the model allows to examine the macroeconomic transmission of standard aggregate shocks at the new steady state associated to the rolled out policy, enabling as such an assessment not only of how green industrial policy transmits as a permanent shock, but also how it alters the transmission of aggregate transitory shocks from a business cycle perspective.

Concretely, the model could begin by closely tracking and adapting the highly relevant augmented NK models in either Coenen et al. (2024) or Del Negro et al (2023) to include the above features, on the blueprint of Rosso (2025), resulting in a "Double TANK" model with households ex ante differentiated between core-unconstrained, core-constrained, periphery-unconstrained, and periphery-constrained types according to exogenous measures/densities targeted in the model estimation phase. The introduction of agent heterogeneity (HANK) from idiosyncratic risks, beyond fixed household types, would constitute a secondary, interesting extension.

The model estimation phase can use either fully-fledged Bayesian estimation, the gold standard for DSGE model estimation, with UK aggregate macro series and partly calibrated structural parameters based on the reviewed literature. This involves setting up priors for all the parameters to be estimated, solving the model in the state space (see software below), and using the recursive law of motion to construct via the Kalman Filter the (conditional) likelihood function for posterior updating and drawing. An alternative, at least initially, is to instead estimate the model by Impulse Response Function (IRF) matching. In particular, following best practice for the estimation of NK models, this involves estimating the model by minimising a norm in the deviation of the model IRFs, obtained through the state-space or recursive solution, and the empirical IRFs to UK monetary policy shocks. To go down this second route, an idea is to use the UK monetary surprises/monetary policy shock series isolated by Cesa-Bianchi et al. (2020) through high-frequency identification. The IRFs of the targeted variables, including (novelly) distributional metrics such as mean log deviations in consumption can be obtained by running Jordà (2005) linear local projections (LPs) of the requisite shocked variables on the identified monetary surprises series and controls.

3.4 Software

The modelling, estimation, and simulation based analyses are computation intensive. The model solution and analysis in the state space, necessary to obtain the recursive law of motion for the estimation phase and examining the transmission of aggregate shocks, will be implemented through DYNARE, the leading software for the analysis of DSGE models, running natively in MATLAB. MATLAB is more generally employed for sequence space solutions and other, non-DSGE specific routines, including the IRF loss minimisation for estimation by IRF matching. For empirical work, particularly the cleaning of the series and Jordà Local Projections, R/RStudio will be the default option.

5. Conclusion

The green industrial transition, understood as broad-based substitution of “dirty” energy inputs with “clean” ones in industrial production and household nondurable consumption, is a central component of Eurozone and UK short-to-medium term industrial and innovation policy plans as laid out in the Draghi Report and UK Invest 2035. Assessing its consequences for short and medium term macroeconomic dynamics is therefore an urgent exercise, calling for the development of models to examine the macroeconomic transmission of green industrial policy in a short-to-medium run perspective and to serve as quantitative policy labs. This proposal has taken stock of the nascent DSGE literature on such transmission, and argued for the analysis of the macroeconomic transmission from (alternative) green industrial policy tools to distributional and economic inequality outcomes, alongside and with implications for monetary and real aggregates, as a key current research gap. Then, it outlined the main aspects of the proposed modelling strategy, including the development of the DSGE model for simulation-based policy analysis and two routes to estimating it against UK data.

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