Policy Designs of a Just Transition in Austria: Testing potential outcomes with IO-SFC Modeling

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Abstract

In current times of polycrisis the need for a transition towards a post carbon economy and more equitable society is evident and largely undisputed within current research agendas. A large body of research has been growing on the design of this transformation to achieve the common goal of a sustainable future in a just manner. Within this research framework we aim to define a stock flow consistent model which entails an equitable and fair transitional process away from fossil fuels and towards a post carbon economy and society. Subsequently, we will present our empirical IO-SFC model for Austria based on Eurostat (2024b) data. Our goal is to estimate the effect of economic policy scenarios on output and employment throughout the different “green” and “brown” sectors. We then aim to identify regions in Austria that are particularly affected by job losses and others paying a crucial role in the reduction of emissions to raise the structural importance of sectors within the transition. These regions will require particular attention by policymakers to guarantee this just transition and our research should provide assistance to policymakers.

In der Zeit der Vielfachkrise ist die Notwendigkeit des Übergangs zu einer postfossilen Wirtschaft und gerechteren Gesellschaft notwendig und mehrheitlich unbestritten innerhalb aktueller Forschungsagenden. Großteils steht dabei der Entwurf möglicher Transformationsprozesse in Richtung nachhaltiger Zukunft im Zentrum der Forschung. Innerhalb dieser Debatte planen wir ein stock-flow consistent Modell zu entwickeln, mit welchem diese Szenarien simuliert werden können. Dabei integrieren wir Input-Output-Statistiken, basierend auf Daten von Eurostat (2024b). Unser Ziel ist es dabei, den Effekt von wirtschaftspolitischen Szenarien auf Produktion und Beschäftigung in verschiedenen – mehr oder weniger schadstoffemittierenden – Sektoren in Österreichs zu schätzen. In der langen Frist ist die Hoffnung mit dem Modell aus diesem Projekt einzelne Regionen in Österreich zu identifizieren, welche besondere Aufmerksamkeit von politischen Entscheidungsträger:innen benötigen.

1. Introduction: Importance of a just transition and its recent history

More than a decade ago, humanity passed several planetary boundaries including ecological limits and biodiversity extinction (García-García et al., 2020). A parallel development is evident which brings about exacerbating levels of inequality, poverty and increasing discrimination. Following from that, a transformation towards sustainability is of requisite and needs to address not only profound environmental but also social challenges (Bennett et al., 2019). Thereby, these must not be address individually by single institutions, but one needs to take up a global perspective, which grasps world's multiple realities (McCauley & Heffron, 2018). This is where the concept of a just transition comes in, which aims to incorporate the dual crisis by considering socioeconomic concerns and the energy transition together (García-García et al., 2020).

Grounding in contemporary history, the claim for a just transition originally stems from labor union movements from the 1980ies and was particularly concerned with the threat to energy-related jobs and highly polluting industries caused by environmental legislation (Abraham, 2017). The first concept of workers protection due to structural changes within industries was noted in the 1970s and was rapidly adopted by unions, environmental groups and governments (Stark et al., 2023). The foundational idea aimed to bring together the social environmentalism of the 1950ies with the claim for environmental health and safety imprinting the following two decades (García-García et al., 2020). This is closely linked to what we understand now as climate and environmental justice.

The utilization of concept of a just transition goes back to the 1980ies in the US, where labor unions were fighting for the remuneration of workers in polluting industries while preserving their dignity (Abraham, 2017; Stevis & Felli, 2016). Tony Mazzocchi, an American unionist affiliated with the Oil, Chemical and Atomic Workers' Union, is closely tied to with the origin of the climate justice movement motivated by the protection of the workers' rights from the threats of environmental policies to polluting industries (Abraham, 2017; García-García et al., 2020; Stark et al., 2023; Stevis & Felli, 2020).

Over the more recent years, the deployment declined sharply in the US while experiencing a great upswing in the rest of the world and particularly in the European Union and by representors of the United Nations (García-García et al., 2020). In the course of this article, we want to delve into the

2. Definition of a Just Transition

A just transition can be generally understood as "fair and equitable process of moving toward a postcarbon society" as defined by McCauley & Heffron (2018, p. 2). This particularly entails the shift away from industries exerting highly extractive activities referred to as "brown" industries, towards "green" industries, highly sustainable sectors (Stark et al., 2023). At the core of the just transition framework lies the workers protection for workers displaced by environmental reforms in the transition away from fossil fuel reliance (Abraham, 2017; McCauley & Heffron, 2018).

To steer towards a post carbon future in an equitable and just manner, those who are lacking access to energy supply, those living in energy poverty as well as those whose subsistence depends upon fossil fuel economy must be primarily supported in the transitional process

(Newell & Mulvaney, 2013). Thus, the role of energy justice is raised within the just transition framework, being of equal importance to climate and environmental justice concerns (Stark et al., 2023). The different forms of justice frameworks will be picked up at a later point again in more detail.

Most importantly, this transition must involve corporatist industrial planning and militant action (Abraham, 2017). In order to address the energy and climate damaging trajectories, a combination of novel technologies, different sources of finance and profound reforms are required (Newell & Mulvaney, 2013). Thereby the matters of justice and equity are intrinsic to the enforcement of a just transition and they need to be complemented within the global justice concerns capturing dimensions of income, ethnicity and gender for developed and developing countries (McCauley & Heffron, 2018). Resulting from that, the state's role as well as the role of global institutions are viewed of undisputed importance within this context.

What is evident from that is that there is no universally applicable definition of the just transition framework, promoting challenges for the governance level and creating the need for a case specific elaboration (Stark et al., 2023).

As the body of research on just transition has developed, researchers discerned that they should aim for alleviating the standing of jobs at the core of concept to prevent the "job vs climate" frame (McCauley & Heffron, 2018). The contestation must be diminished through the incorporation of several stakeholders since otherwise, a division between the labor movement and the community's interests would emerge. "The just transition frame of combining both an environmental and jobs focus is identified as a potential turning point."(McCauley & Heffron, 2018, p. 3). Thus, a just transition should be understood as the intersection point of climate and labor policies (Velicu & Barca, 2020).

2.1 Industries affected

Industries which are of particular importance in the decarbonization process are the transport and energy sectors (Abram et al., 2022; Bennett et al., 2019). Consequences of the transitional process in these industries will likely affect millions of people through various channels and policy spheres such as housing, health, industrial policy and social welfare. Thus, the policy action of a JT cannot be limited to one arena (Abram et al., 2022). One needs to adopt a broader perspective on sustainability and equity ranging from the effects of highly emitting industries on workers to concerns such as including food justice or energy sovereignty (Stark et al., 2023).

2.2 Actors and actions

Vital to the just transition process are the questions of the political economy addressing the topic of "who wins, who loses, how and why" since they reveal the distributional aspects e.g. of the energy distribution as well as the most impacted communities from the side effects of production, extraction and generation (Newell & Mulvaney, 2013). Moreover, the incurrence of the social costs stemming from decarbonizing industries can be disclosed.

To embellish the transitional process in a just manner, researchers agree that a JT cannot be left to the "free" market dynamics as a more interventionist governance style is needed and the complexity, the scale and the various interests involved surpass market capabilities (Stark et al., 2023). Thus, governments play a critical role in the provisioning of social safety nets, in the creation of green jobs and more generally mitigating negative environmental or social externalities of capitalism through e.g. taxation. In addition, it acts as a mediator of competing powerful interests especially in the transformation process of the energy sector (Newell & Mulvaney, 2013).

Questioning the (global) power structures is a pressuring aspect of the transformation. The interests of the global elites commonly clash with the needs of the economically deprived communities in respect to their energy needs and environmental vulnerability (Newell & Mulvaney, 2013). A just transition requires not only the managing of current trade-offs among different interests but also addressing complex issues of historical responsibility and inequitable use of global resources, which pertains to the matter of who bears the costs for the transition. To strive against this power inequalities, a *global* justice framework must be incorporated in a just transition. Moreover, the energy production and consumption are governed mostly by a view global players within the private sector. Through that, global actors supporting the just transition have limited in their ability to steer/navigate the tradeoffs within the tackling of energy injustice, energy poverty and the climate justice concurrently (Newell & Mulvaney, 2013).

As defined by the just transition research collaborative one can differentiate between 4 approaches to tackle the transformation in a just manner . The *status quo approaches* preserve the capitalist system and place confidence in the private, voluntary and market-based greening. The *managerial reform approaches* acknowledge the importance of public policies while refraining from further scrutinizing the power structures. The *structural reform approaches* and the *transformative approaches* are the most progressive forms of accomplishing a just transition. The former emphasizes the importance of redistributing power to counteract social poverty, while the latter promotes a radical system change and levels criticism against the capitalist order. The responsibility of negative environmental and social consequences is attributed to the underlying economic system.

2.3 Economic consequences

The consequences the economy faces are not definite especially when it comes to the long-term impacts on employment (Stark et al., 2023). The decarbonization process related to the just transition will implicate changes in the markup of employment and job creation as well as losses within "brown" or carbon intensive industries. Consequently, researchers agree on that a small but positive effect on net employment is expected and a negative repercussion on the income distribution (García-García et al., 2020). The altered composition of the labor market will have further implications to the whole economy through the propagation of effects from the supply chains and income variations. "The net balance of jobs would be a result of demand levels, investment, trade flows and labour elasticity" as stated by (García-García et al., 2020, p. 4). What is important to point out here is that one should not solely focus on the net effects of employment but put more emphasis on the job quality as well as the skills of employees.

Overall, the research is lacking in the comprehensive analysis of income dynamics and the effects on the quality of jobs, the development of working hours and the effect on gender (García-García et al., 2020). In our analysis we aim to close this research gap by building a stock-flow consistent model of 9 sectors and estimate the effects of a just transition on the whole economy putting a particular emphasis on the labor market dynamics.

3. Corporatism – Austria as a special case

Corporatism exhibits a crucial role in a just transition process and is of particular importance in the case of Austria, since the country is well known for its special form of corporatism the "Sozialpartnerschaft".

Corporatism can be defined as joint industrial policy making between representatives of labor (employees) and capital (employers) (Abraham, 2017; García-García et al., 2020). This form of industrial relations aims for the preempting of the class struggle. However, corporatism is also subject of considerable criticism since it is argued that erodes unions militancy and weakens workers resistant towards their employers. Moreover, environmentalists are voicing criticism towards corporatism since they cooperation between workers, capitalists and agents of the state are blocking environmentalists' input for policy making and reinforces the power of small interest groups.

Nevertheless, corporatism permits the long term planning of industrial policies and through that it contributes to the sustainability of just transition, environmental reforms (Abraham, 2017). Worker's militancy is maintained provided that workers constantly fight for the expansion of the democratization of corporatist institutions and by that guarantee their participation in industrial policy decision-making.

A historical examination of different forms of corporatism reveals the importance of democratic input for the respondence to environmental legislation (Abraham, 2017). The neo-corporatist practice of Germany is marked by a robust industrial democracy and thus facilitates a just transition. Even though the US unions, as emphasized before, acted as a "pioneer" in the just transition, they were unable to maintain their militancy and lost their influence in industrial decision making thought the late 1970ies and the Reagan aera. Consequently, the unions are now showing a lack of interest in environmental and just policy settings since they lost their institutional leverage and power to meaningfully participate in the agenda setting of a just transition.

4. Justice Scholarships

The just transition concept builds bridges between different justice scholarships, climate, energy and environmental justice (McCauley & Heffron, 2018). Through that one is able to adopt an integrated, whole-system perspective on justice which can assist in discerning systematic answers to socio-economic and environmental questions which we will later refer to as triumvirate tenants (Abram et al., 2022; Stark et al., 2023).

The different scholarships must be integrated in order to confront areas where injustices arise and to find a way to combat them (McCauley & Heffron, 2018). Environmental justice is focused on achieving a balance between the environmental and social aspects involved in a just transition. Climate justice is particularly concerned with the global dimension of a just transition and puts emphasis on the implications of the rapid, inevitable climate change for endangered populations especially in the Global South. What is more, Energy Justice addresses the transformation of the energy production towards low carbon sources and the energy efficiency within consumption in the long term. Concurrently, the cohesion of the community and the wellbeing of individuals cannot be relinquished for an energy transition.

Among these various justice scholarships, the triumvirate tenants exhibit a crucial role in the conceptualization of justice within the just transition, incorporating the distributional, recognitional and procedural justice (Stark et al., 2023).

The *distributional justice* refers to the equitability in the allocation of benefits and harms of environmental actions and decisions across different groups as well as space and time (Bennett et al., 2019). This particularly applies to reemployment plans, energy access and security and focuses on the disproportionate affectedness of minority groups e.g. in the economic exploitation of fossil fuel economies which can be combat by the energy transition (McCauley & Heffron, 2018; Stark et al., 2023). What the concept fails to acknowledge is the importance of foundation of society, the care sector, both paid and unpaid (Stark et al., 2023).

Further, the *recognitional justice* concepts directs the attention to the recognition of all needs and concerns of all groups within society (Stark et al., 2023). At the core is "the acknowledgement of and respect for pre-existing governance arrangements as well as the distinct rights, worldviews, knowledge, needs, livelihoods, histories and cultures of different groups in decisions" (Bennett et al., 2019, p. 4). Historically marginalized groups play a substantial role in the decision-making process, which should particular involve indigenous people, women and migrant worker (Stark et al., 2023). Thereby community action and the inclusion of these groups in the decision making are curial to recognitional justice.

Lastly, procedural justice guarantees the influence of those most affected by a just transition, such that they do not only sit on the table in the decision-making process but also have their voices heard (Stark et al., 2023). The inclusiveness of the decision making process lies within the consideration of all voices raised to an equivalent extent and consult affected parties adequately (Abram et al., 2022; Bennett et al., 2019; García-García et al., 2020).

4. How to model a just transition?

The previous chapter has discussed why a just transition is necessary and how it potentially could be implemented. To assist policymakers in developing just transition programs an understanding of how different economic variables and the environment interact with each other is necessary. Macroeconomic modelling can help to estimate how certain economic policies potentially affect production, employment levels and debt levels on the one side and greenhouse gas emissions or changes in land use on the other side. Before introducing our own model – which at this stage is a very down-scaled prototype – we will briefly discuss how other researchers answered similar questions before. What these models have in common is that they reject the mainstream notion of macroeconomic models having to be micro-founded and instead start with aggregate national accounts data and then disaggregate them to describe and model macroeconomic processes (Storm, 2021).

4.1 The VAR approach

A classic macro-econometric approach to model the inter-dependency of macroeconomic time series is the vector autoregression method introduced by Sims (1980). It is commonly used to estimate the reaction of macroeconomic variables to a shock in one variable.

In the context of discussing questions regarding a just transition, an application of said method can for example be found at Onaran and Oyvat (2023). They estimate the effects of a one-off increase in public spending in the care and green economy on male and female employment levels as well as GDP in the Republic of Korea, concluding that multiplicator effects for these public spending programs are significant and relatively large. Similarly, although not focused on employment levels, Kapeller et al. (2021) estimate semi-structural VAR models for the EU27 to investigate the impact of large-scale public investment programs. They show that these investment programs are fiscally sustainable, since they have large multipliers and can potentially bring down debt-to-GDP ratios due to increased economic activity. Due to data concerns, Kapeller et al. (2021) are not able to distinguish between green and non-green investments in their research. Just focusing on the differences between green energy and fossil energy investments, Batini et al. (2022) could in contrast show, that multipliers on green investment are larger than their counterparts, which hints at the potential of green investment programs to be beneficial for economic progress.

While VAR models are useful to investigate the relationship between a limited number of macroeconomic time series, they quickly reach their limits when many variables are included. Thus, if researchers plan on exploring the effects of economic policies on growth, employment in different sectors, financial markets and potentially also on environmental indicators and variables, different approaches have to be found.

4.2 Stock-flow consistent models

Aforementioned questions can likely better be answered by the more holistic modeling approach provided by the class of Stock-flow consistent models. While the roots of SFC modeling lie further back in the past, a through and extensive re-introduction of the approach can be found in the book *Monetary Economics* by Godley and Lavoie (2007), which has sparked new interest in the field. A more recent survey of this promising type of macroeconomic models is supplied by Nikiforos and Zezza (2017). They identify the four core principles of SFC models. Every monetary flow has to come from somewhere and go somewhere (flow consistency), the assets of one agent have to be the liabilities of another sector (stock consistency), every flow has to imply a change in one or more stocks (stock-flow consistency) and every financial transaction necessitates a quadruple accounting entry. SFC models are fundamentally post-Keynesian and demand driven. They integrate the real and the financial economy in one model and can be useful to analyze the effect of different policies and macroeconomic scenarios. SFC models exist both on a global level as well as for specific regions and countries, they can be both theoretical and empirical. A model for Austria was constructed by Schmelzer and Miess (2018), while Mazier and Reyes-Ortiz (2024) provide a model for the French economy and Canelli et al. (2022) estimate a regional model for the Italian region of Campania.

Recently, SFC models have also been increasingly used in the field of ecological economics to model the interaction of the economy and the environment. Dafermos and Nikolaidi (2022) use their DEFINE model, which integrates monetary flows and stocks with their physical counterparts, to simulate the effect of different climate policies. While the DEFINE model works on a global scale, George and Dafermos (2023) provide a modeling approach specifically for the simulation of climate policy effects in the United Kingdom.

Like all empirical modeling approaches, SFC models depend on the existence of reliable data with enough periods of observation to calibrate and estimate the model. SFC models mainly use national accounts data, which has the advantage that it exists for many countries with satisfactory accuracy and good comparability, since ESA 2010 and SNA 2008 provide definitions and classifications that the respective statistical authorities must adhere to. These data sets are usually prepared in a highly aggregated manner. This is sufficient when one tries to estimate the effect of green economic policies on unemployment rate at the national level, like George and Dafermos (2023) do, for example. However, problems arise in the process of analyzing the effect of said policies on production and employment levels in different industries, which is highly relevant when talking about securing a just transition.

A potential remedy to this issue is provided by Valdecantos (2021) who presents a stock-flow consistent input-output model in his paper, which makes it possible to have industry-specific tax rates, subsidies or government consumption. Thus, more sophisticated scenarios can be developed within the model. Valdecantos (2021) for example simulates a decrease in demand for fossil energy or increased energy efficiency in some highly polluting sectors, which in “standard” SFC models would not be possible. His paper therefore offers a lot of insight on how models that want to analyze the reaction of different industries to changing fundamental conditions have to be constructed.

5. Data and the model

We will now introduce the prototype of our stock-flow consistent input-output model for Austria and the data we have used to develop it. Currently, this model is far from complete, ignores certain parts of the economy completely and attaches little importance to other aspects that are usually relevant in SFC models. We will talk about current deficiencies and potential extension later in the paper. In this version attention was paid above all to the real sector of the economy. Thus, this version of the model can simulate how production and employment in different economic sectors react to certain policy scenarios. So far, however, it does not take other relevant factors like imports and exports or government debt into account.

5.1 Data sources

The primary data repository for our analysis constitutes Eurostat national accounts data (Eurostat, 2024b). In addition, Eurostat also provides data on air emission accounts by NACE activity (Eurostat, 2024a). In our analysis, we do not include the activities of extraterritorial organizations and bodies, since this activity merely is a placeholder activity in all used datasets. Data on inflation is provided by the Austrian Federal Statistical Office (STATISTIK AUSTRIA, 2024), while data on ECB interest rates for main refinancing operations was accessed on the website of the German Bundesbank (Deutsche Bundesbank, 2024). Finally, we obtained data on historical population and population projections from OECD (2023). Typically, data from the periods 2002 until 2019 is used, so that we include only the period after the introduction of the Euro and before the outbreak of the COVID pandemic.

5.2 Industry aggregation

Eurostat national accounts data and input-output tables are available at the NACE A*64 aggregation level. This has several drawbacks that are relevant to our modeling task. One the one hand, this aggregation level is sometimes too high to properly distinguish between “green” and “brown” activities. For example, there only exists the activity “electricity, gas, steam and air conditioning supply”, which does not differentiate between fossil and renewable energy sources. This was also brought up by Kapeller et al. (2021) when they discussed the difficulty of investigating the difference between the effects of green and non-green investment. On the other hand, 63 industries are also too many to perform simulations whose results are usable in a policy evaluation case.

Therefore, we decided to aggregate the 64 activities into 9 groups that make sense both from their role in the economy as a whole and their level of “greenness”. Table 2 in the annex shows all 63 included activities, their emission intensity in kilograms per euro gross value added and their respective sector in the model. Sector 1 includes manufacturing activities with high emission intensity, we call this sector “brown manufacturing”. Sector 2 is comprised of manufacturing sectors with low to medium emission intensity. It would be wrong to call this sector “green”, since some of the included activities like the production of rubber and plastic products most likely are not describable as green while others contain both potentially green and non-green activities. Like we have discussed before, we are not able to separate the production of electric busses from the production of diesel cars. Continuing, sector 3 consists of activities regarding the extraction of resources, like crop and animal production or mining. Sector 4 is the largest sector, as it includes various service activities, amongst them for example retail trade, advertising and market research or financial service activities. Then, sector 5 consists of water and air transport which shows a much higher emissions intensity than land transport, which is the only activity in sector 6. Similarly, construction is the only activity in sector 7, while sector 8 is comprised of various social services like education or human health activities. Finally, sector 9 covers electricity, water collection or sewerage and waste management.

5.3 The model

As mentioned before, this model is a prototype in the early stages of development. Table 1 shows the Transaction Flow Matrix at the current state, including the most relevant flows.

Flows	***Industries 1-9***	***Households***	***Government***	***Total***
Intermediate Purchases	+INTP -INTP			0
Final Consumption	+CONS	-CONS_H	-CONS_G	0
GFCF	+/-GFCF			0
Wages	-WB	+WB	0	0
Taxes	-T_IND -T_INC	-T_INC	+T_IND +T_INC	0
Social Contributions	-SC_EMP	-SC_H	+SC_EMP +SC_H	0
Transfers	0	+TRANSFERS	-TRANSFERS	0

Table 1: Transaction Flow Matrix

We can see observe that industries buy intermediate products from each other, while final demand comes both from household and government consumption, as well as the gross fixed capital formation from other industries. In the current stage we do not take household and government fixed consumption into account, this naturally will be added later. Wages are paid exclusively by our industries, these also include wages paid by the government, since activities like public administration and defense, education or human health activities at least partially include public jobs. Industries pay both indirect taxes (like value added taxes or carbon taxes) as well as income taxes on their profits, while households only pay income taxes. This of course covers only a fraction of the total tax system, a more sophisticated way to model taxes will again be added in later versions of the model. Social contributions are paid by both industries and households, while only households receive transfers from the government.

5.4 Behavioral equations

We now come to the equations that govern our model. Similar to Valdecantos (2021), equation (1) shows that the production of sector i at time t is comprised of the intermediate purchases of all sectors from sector i at time t, the household and government consumption of goods and services produced by sector i at time t, as well as a fraction of total gross fixed capital formation. This fraction is determined by the coefficient a_i, which is calculated from the input-output table by dividing the amount that GFCF contributes to sector i's final demand by the total sum of GFCF. This coefficient, like most other coefficients, was calculated only with data from 2019, to account for potentially changes in production technology or supply chains.

$$(1)\ PROD_{i,t} = \sum_{j=1}^{9} INTP_{j\ i,t} + CONS_{H\ i,t} + CONS_{G\ i,t} + a_i GFCF_t$$

$$(2)\ INTP_{j,i,t} = a_{j\ i} PROD_{j,t}$$

$$(3)\ GVA_{i,t} = PROD_{i,t} - INTP_{i,t}$$

$$(4)\ NOS_{i,t} = GVA_{i,t} - WB_{i,t} - SC_{i,t} - T_{i,t}^{IND} - ck_i PROD_{i,t}$$

$$(5)\ SC_{i,t} = 0.213 * WB_{i,t}$$

$$(6)\ T_{i,t}^{IND} = t_i^{IND}(GVA_{i,t} + GFCF_{i,t})$$

$$(7)\ PROF_{i,t} = (1 - 0.1735) NOS_{i,t}$$

Equation (2) presents the intermediate purchases of sector j from sector i at time t. It is calculated by multiplying the input coefficient of sector j from sector i times the total production of sector j. Equation (3) then simply defines gross value added by sector i in time period t as the difference between production and intermediate purchase. The net overall surplus of sector i at time t is the difference between GVA and the wage bill, social security contributions, indirect taxes and consumption of fixed capital of sector i at time t, as seen in equation (4). Sectors pay 21,3% of their wage bill as social security contributions, which was calculated from national accounts data from 2019, which is noted in equation (5). In equation (6) the indirect taxes paid by sector i at time t are calculated as the sector-specific indirect tax rate times GVA and GFCF from the sector. These tax rates were calculated again for 2019 by dividing the sum of taxes minus subsidies on products and production. In our simulation we can thus modify the tax rates to simulate for example changes in carbon taxation or government subsidies. Equation (7) then shows the profit obtained by sector i at time t, which is 0.8625 (the tax rate on profits) times the net overall surplus of sector i at time t. Again, this tax rate was calculated from national accounts data.

$$(8)\ GFCF_{i,t} = i_{0\ i} + i_{1\ i} PROF_{i,t-1} + i_{2\ i}\left(r_{i,t} - \pi\right) + i_{3\ i} u_{i,t}$$

$$(9)\ u_{i,t} = \frac{GVA_{i,t}}{K_{i,t}}$$

$$(10)\ K_{i,t} = K_{i,t-1} + GFCF_{i,t-1} + ck_i PROD_{i,t-1}$$

In equation (8) the formula for gross fixed capital formation of sector i at time t is presented. It depends on a sector-specific intercept as well as the profits from the previous period, the real inflation rate and the sector's capital utilization rate. Parameters i_0 to i_3 are sector-specific and calibrated by an OLS regression using data from 2002 until 2019. Equation (9) defines the capital utilization rate as the ratio between gross value added of sector i at time t and the capital stock of sector i at time t. Subsequently, the capital stock of sector i at time t is determined by the capital stock, gross fixed capital formation and the consumption of fixed capital from the previous period.

$$(11)\ p_{i,t} = (1 + \mu_i) * (\sum_{j=1}^{9} a_{i,j} p_j + a_{i,l} w_i + t_i^{IND})$$

$$(12)\ \pi = (\sum_{i=1}^{9} a_{H,i} p_{i,t} - \sum_{i=1}^{9} a_{H,i} p_{i,t-1}) / \sum_{i=1}^{9} a_{H,i} p_{i,t-1}$$

Equation (11) – still analogous to Valdecantos (2011) – defines the price level in sector i at time t as the sector-specific profit mark-up times the price level of all individual sectors weighted by the input coefficient plus the wage level of sector i times the input coefficient of labor as well as the indirect tax rate of sector i. The growth rate of the sum of all price levels weighted by the household consumption coefficient, which states how much of the total household consumption goes into a specific sector, is the inflation rate depicted in equation (12).

$$(13)\ INC_{H\,t} = \sum_{i=1}^{9} WB_{i,t} + TRANSFERS_t - T_{H\,t}^{INC} - SC_{H\,t}$$

$$(14)\ CONS_{H\,i,t} = a_{H\,i} INC_{H,t}$$

$$(15)\ L_{i,t} = a_{l,i} PROD_{i,t}$$

$$(16)\ WB_{i,t} = w_{i,t} L_{i,t}$$

$$(17)\ w_{i,t} = w_{i,t} + \gamma_i w_{i,t-1}$$

$$(18)\ T_{H\,t}^{INC} = 0.275 * WB_t$$

$$(19)\ SC_{H\,t} = 0.197 * WB_t$$

Equation (13) shows that the income of private households at time t consists of the sum of sector wage bills, transfers received by the government minus income taxes and employee social contributions at time t. The calculation of income taxes and social security contributions can be seen in equations (18) and (19), the tax rates are calculated using national accounts data from 2019. In equation (14) it is defined that household consume their entire income. This might not be realistic per se, without the inclusion of further transfers and profit distribution from industries to households it leads to a total consumption sum that is close to reality though. Equation (14) furthermore shows that the household consumption of goods and services produced by sector i depends on the household consumption coefficient $a_{H,i}$ that was already presented before. The demand for labor in sector i at time t is calculated in equation (15) by multiplying the production of sector i at time t with the input coefficient for labor of sector i. The input coefficient for labour was calculated from national accounts data by dividing the number of employees in the sector by production as defined in equation (1). Thus, in the current stage of our model more labor is demanded per produced Euro than in reality, since the additional production caused by exports is missing. This, although it may sound contradictory, is the desired outcome. Otherwise, we would later observe a sudden decrease in employment, as soon as exports no longer affect production levels. The wage bill of sector i at time t in equation (16) is then obtained by multiplying the demand for labor with the average yearly wage of sector i at time t, which as is observable in equation (17) grows each year by a constant sector-specific percentage.

$$(20)\ GAP_t = \frac{GVA_t - \left(\frac{GVA_t}{L_t} * POP_{15-64}\right)}{\frac{GVA_t}{L_t} * POP_{15-64}}$$

$$(21)\ CONS_{G\,t} = g_0 POP + g_1 POP_{0-20} + g_2 POP_{65plus}$$

$$(22)\ TRANSFERS_t = v_0 POP + v_1 \frac{L}{POP_{15-64}} + v_2 POP_{0-20} + v_3 POP_{65plus}$$

$$(23)\ r_t = r_{t-1} + \zeta_1 GAP_{t-1} + \zeta_2 (\pi_{t-1} - 0.02)$$

The output gap in our model is defined in equation (20) as the gap between actual GVA across all sectors in period t and the potential output, which is specified as GVA per unit of deployed labor times working age population. Government consumption and transfers are econometrically calibrated, as seen in equations (21) and (22) and depend on the total population, the population under the age of 20 as well as above the age of 65 and – for government transfers only – the unemployment rate calculated as percentage of deployed labor amongst the total population between 15 and 64. The central bank is modelled to follow a version of the Taylor rule in equation 23, it changes the nominal interest rate from its value in the previous period depending on the output gap and the difference between actual inflation and the 2% inflation target. The parameters $zeta_1$ and $zeta_2$ again are calibrated by OLS for data from 2002 until 2019.

6. Preliminary Findings

At the current stage, our preliminary findings are very limited and do not allow significant conclusions to be drawn.

6. Conclusion

From our analysis we can conclude that for a just transitional process, a comprehensive transition plan is of particular importance. The necessary policy instruments exhibit far-reaching effects on the overall economy and the labor market in particular. Thus, to assess which policy measures should be implemented, macroeconomic models should be supplied by policy makers to provide assistance. Drawing from our analysis we can infer that input output stock flow consistent modelling establishes an effective conceptualization with adequate consideration of numerous scenarios.

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Annex

Table 2 : Categorization of NACE Codes into 9 Sectors

NACE Code	*Sector in model*	*Activity*	*Kilograms CO^2 equivalent per € GVA*
A01	3	Crop and animal production, hunting and service activities	2.57888
A02	3	Forestry and logging	0.11363
A03	3	Fishing and agriculture	0.06295
B	3	Mining and Quarrying	0.75493
C10-C12	2	Manufacture of food products; beverages and tobacco products	0.13791
C13-C15	2	Manufacture of textiles; wearing apparel, leather and related products	0.07095
C16	2	Manufacture of wood and cork, expect furniture; manufacture of articles of straw and plaiting materials	0.08794
C17	1	Manufacture of paper and paper products	0.88196
C18	2	Printing and reproduction of recorded media	0.00624
C19	1	Manufacture of coke and refined petroleum products	2.5468
C20	1	Manufacture of chemicals and chemical products	0.83514
C21	2	Manufacture of basic pharmaceutical products and pharmaceutical preparations	0.00566
C22	2	Manufacture of rubber and plastic products	0.02838
C23	1	Manufacture of other non-metallic mineral products	1.82081
C24	1	Manufacture of basic metals	2.98769
C25	2	Manufacture of fabricated metal products, except machinery and equipment	0.03117
C26	2	Manufacture of computer, electronic and optical products	0.02722
C27	2	Manufacture of electrical equipment	0.01624
C28	2	Manufacture of machinery and equipment n.e.c.	0.0126
C29	2	Manufacture of motor vehicles, trailers and semi-trailers	0.01939
C30	2	Manufacture of other transport equipment	0.00572
C31_C32	2	Manufacture of furniture; other manufacturing	0.01698
C33	2	Repair and installation of machinery and equipment	0.01434
D	9	Electricity, gas, steam and air conditioning supply	1.2212
E36	9	Water collection, treatment and supply	0.02535
E37-E39	9	Sewerage, waste management, remediation activities	0.76151
F	7	Construction	0.04693
G45	4	Wholesale and retail trade and repair of motor vehicles and motorcycles	0.02847
G46	4	Wholesale trade, except of motor vehicles and motorcycles	0.04458
G47	4	Retail trade, except of motor vehicles and motorcycles	0.04066
H49	6	Land transport and transport via pipelines	0.34165
H50	5	Water transport	2.4158
H51	5	Air transport	6.242
H52	4	Warehousing and support activities for transportation	0.02486
H53	4	Postal and courier activities	0.06381
I	4	Accommodation and food service activities	0.02107
J58	4	Publishing activities	0.00533
J59_J60	4	Motion picture, video, television programme production; programming and broadcasting activities	0.00337
J61	4	Telecommunications	0.0022

J62_J63	4	Computer programming, consultancy, and information service activities	0.00526
K64	4	Financial service activities, except insurance and pension funding	0.00539
K65	4	Insurance, reinsurance and pension funding, except compulsory social security	0.00424
K66	4	Activities auxiliary to financial services and insurance activities	0.00639
L	4	Real estate activities	0.00148
M69_M70	4	Legal and accounting activities; activities of head offices; management consultancy activities	0.00633
M71	4	Architectural and engineering activities; technical testing and analysis	0.00642
M72	4	Scientific research and development	0.00382
M73	4	Advertising and market research	0.00641
M74_M75	4	Other professional, scientific and technical activities; veterinary activities	0.08935
N77	4	Rental and leasing activities	0.04227
N78	4	Employment activities	0.00319
N79	4	Travel agency, tour operator reservation service and related activities	0.0663
N80-N82	4	Security and investigation, service and landscape, office administrative and support activities	0.02103
O	8	Public administration and defence; compulsory social security	0.02377
P	8	Education	0.00443
Q86	8	Human health activities	0.01001
Q87_Q88	8	Residential care activities and social work activities without accommodation	0.0079
R90-R92	4	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities	0.02466
R93	4	Sports activities and amusement and recreation activities	0.02369
S94	4	Activities of membership organisations	0.03852
S95	4	Repair of computers and personal and household goods	0.01967
S96	4	Other personal service activities	0.03427
T	4	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	0