The role of autonomous adaptation in global assessments at global level

Key Messages

- Autonomous adaptation is a process in market economy in which institutions, enterprises or communities adjust to changing climate conditions. Investigating autonomous adaptation contributes to understanding of how various market and public policies could strengthen overall climate resilience.

- Computable general equilibrium models are well suited for the examination of autonomous adaptation at global and national levels. These models are based on general equilibrium mechanisms which reflect the market mechanisms underpinning the autonomous adaptation process.

- The model presented in this Insight, CAGE-GEME3, is a static multi-country, multi-sector CGE model of the world economy linking the economies through endogenous bilateral trade. The model was tailored to explore the implications of various possible autonomous adaptation mechanisms.

- Analysis shows that autonomous adaptation to climate shocks substantially reduces the potential climate damages from climate impacts. In global terms, it is estimated that, in a hypothetical case without market adaptation, climate impacts would be higher by approximately a third (compared to a case with market adaptation) both regarding the GDP and welfare losses.

Context

Autonomous adaptation is undertaken by institutions, enterprises or communities independently adjusting to changing climate conditions. It relies on mechanisms which constitute the market economy, hence it is often called private or market-based adaptation. It can be contrasted with planned adaptation which is the result of deliberate policy decision, resulting from recognition that the conditions are expected to change or are already changing, and that some form of action is required to maintain a desired state.

Autonomous adaptation is an important part of adaptation processes as it defines the capacity of society to adapt without planned intervention. Investigating autonomous adaptation can thus help understand which market and public policies can strengthen overall resilience.

This Insight presents a macro-modelling framework that allows for the assessment of autonomous adaptation at European and Member State levels. It also allows for the exploration of the mechanisms through which climate impacts propagate throughout the economy, affecting in the end overall economic activity (GDP) and consumers' welfare.

Policy and methodological developments

The modelling framework

The modelling framework is based on the computable general equilibrium (CGE) class of models. CGE models capture both the direct and indirect effects of autonomous adaptation for the variety of economic agents considered (usually, government, households and firms). The direct autonomous adaptation refers to the changes made by autonomous economic agents when confronted with climate change (Aaheim and Aason, 2008). Examples include using more water or fertilisers in agriculture in order to compensate for lower rainfall. The indirect effect of autonomous adaptation refers to the wider market response of demand and supply resulting from the initial direct effect (Aaheim and Aason, 2008). The propagation of the indirect response in the economy will depend on the specificity of the trade network and can have both domestic and international effects. Those effects are captured with the CGE models.

The bilateral trade linkages, a standard feature in most CGE models, allow for tracking how the
adaptation response in one of the sectors or by one of the agents propagates within the country or region, but also beyond the national border via international trade.

The model employed for this analysis, CAGE-GEME3, is a static multi-country, multi-sector CGE model of the world economy linking the economies through endogenous bilateral trade. The CAGE database is mainly based on the Global Trade Analysis Project (GTAP) database, version 8 (Narayanan et al., 2012).

The CGE analysis of climate impacts follows a static comparative approach (as in e.g. Aaheim et al., 2012; Hertel et al. 2010; and Ciscar et al. 2012), estimating the counterfactual of future climate change (simulated in the 2080s) occurring under the current socioeconomic conditions. Therefore, the climate shock-induced changes would occur in the economy as of today.

The main indicators used for describing the socio-economic effects of climate impacts are GDP and Equivalent Variation (EV). The EV represents change in real consumption (above subsistence level) and is interpreted as a measure of welfare change experienced by people in the respective regions. The two indices not necessarily correlate and can indeed move in different directions.

**Accounting for autonomous adaptation**

Using this modelling framework, simulations can be performed in order to analyse the degree and value of the autonomous adaptation through modifying market-related parameters. The CAGE-GEME3 model was tailored to explore the implications of the various possible autonomous adaptation mechanisms that relate to labour mobility, both across sectors and regions, the degree of substitutability between capital and labour in the production function and the degree of substitutability for trade flows and domestic production.

In particular, the adaptation-related mechanisms include three specific mechanisms. The key parameters to control the autonomous adaptation mechanisms are:

1. Control of labour mobility: specified via a constant elasticity of transformation (CET) function with the elasticity of transformation parameter, mobility, determining the responsiveness of the factors' supply to the wage differentials across different employing sectors.

2. Control of substitution possibilities between capital and labour to account for changes in the available technologies: reduced in the counterfactual experiment to reflect less favourable technological options available to substitute the inputs.

Control of the degree of trade rigidity: This is implemented by modifying the substitution elasticity both between domestically produced and imported goods and services, and between imports from different regions. In order to reduce the adaptive capacity of trade substitution the parameters are reduced with respect to their original values.
The CAGE-GEME3 model was used to explore the role of autonomous adaptation to agricultural yield change and sea level rise associated with climate change. The following scenarios were investigated:

- The benchmark case reflects the current adaptive capacity of the markets.
- The no-adaptation scenario assumes the all-rigid market by restricting trade and the production factors ability to adapt (the degree of substitutability between capital and labour and labour mobility).

Subsequently, the difference in results between the adaptive and rigid scenarios is interpreted as value of autonomous adaptation. An additional semi-rigid scenario assuming rigid trade structure but adaptive factors of production was also investigated to enhance understanding of the roles of the different mechanisms.

The agricultural climate scenario used (A1B IPCC SRES) reflects a global temperature increase of 4°C compared to the pre-industrial level. Global yield loss (excluding the effects of any climate-induced land-use change) is estimated at 5%, although the regional distribution varies strongly. The largest welfare gains from the adaptation process are estimated for the EU-Northern regions. The reason is relatively mild or positive impacts of climate changes on domestic agricultural crops production, so the initial welfare reduction under rigid market conditions is due to higher import prices passed on by trading partners whose agricultural crops production is more affected. Subsequently, the value of adaptation reflects the degree into which these regions can substitute away from the highly priced imports towards more competitive imports and/or domestic production. A somehow opposite mechanism is observed in the EU-Southern regions where, following the climate shock, the domestic prices of agricultural crops rise more than the price of imports, and the adaptation process reflects the regions' ability to substitute towards the relatively low-priced imports.

The scenario for sea level rise assumes a rise of sea level of 0.47m by 2100, which is consistent with the A1B IMAGE scenario. Most of the regions are subject to capital losses below 1%. Results indicate that the change in GDP and welfare reflect the magnitudes of impacts across the EU regions. The northern area of Central Europe records the largest loss, followed by Northern Europe, United Kingdom and Ireland, the southern area of Central Europe and Southern Europe.

The study concludes the following:

- The degree of benefit brought by market adaptation depends on the type of climate impact and on the specificity of domestic and international context for each region. For regions where the impact is mostly passed on through the international trade the adaptation allows for significant alleviation of the negative effects (e.g., agricultural impacts in Northern Europe), while for impacts which have direct impact on welfare (e.g., forced migration due to sea level rise) there is little opportunity for the market mechanisms to reduce the losses.
- For most regions the introduction of market rigidities or, in other words, lower adaptive capacity of the markets, reduces the benefits from positive climate impacts (Northern Europe), or pushes further down reductions in GDP and welfare from negative climate shocks (Central Europe North and Central Europe South). Southern Europe's GDP improves with increase in the rigidity, however welfare declines further.

Main implications and recommendations

Investigating the role of autonomous adaptation through CGE modelling can provide relevant information about the significance of flexible markets in adaptation processes. Results from the application of the modelling framework to global changes in agricultural yields and sea level rise suggest that climate change damages can be substantially reduced if markets can autonomously adapt to climate shocks. In global terms, it is estimated that the rigid case increases the climate impacts by a third (compared to a case with market adaptation), approximately. GDP loss could be 1.4% instead of 1% under more rigid markets. Most of the additional damages due to market rigidities would come associated with the labour market rigidity, rather than more restricted substitution possibilities in international trade. Moreover, concerning the share of the additional losses under rigid markets, most of the additional impacts are due to climate effects on labour productivity and energy demand.
It is important to note that the modelling frameworks still have weaknesses. Firstly, the quantitative estimates are derived from a set of mathematical equations and specific values of key parameters, which represent de facto the idealised functioning of the market economies, yet ignoring the many rigidities and inertia distorting markets. Secondly, the results could differ if alternative characterisations of the market rigidities are applied. Furthermore, a formal decomposition of the climate impacts distinguishing between partial and general equilibrium adjustments would be also valuable to understand the relative importance of the general equilibrium effects, which relate to the indirect autonomous adaptation process.

Results should thus be interpreted as a way to identify trends and mechanisms rather than be a precise quantitative assessment. Moreover, as the coverage of climate impact is quite limited (notably some key climate impacts such as effects on ecosystem services or those associated with passing tipping points are not considered), this analysis does not intend to make a comprehensive assessment of how much private adaptation could reduce climate impacts.

Bibliography


Further Information
Modelling autonomous adaptation with the CAGE-GEME3 model [pdf]

Contact
Wojtek Szewczyk
Partner
Joint Research Centre (JRC)