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URBAN DYNAMICS AND ENERGY CONSTRAINTS: A FORECASTING STUDY

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Overview

Events from the last decade have underlined the instability of the energy situation in Europe and the necessity to be less dependent on fossil fuels. European countries are forced to grapple with how to minimize their oil consumptions and replace them with alternatives, in short: how to survive the post-petroleum age? In order for economies to adapt to the post-petroleum age, relying purely on technological progress might not provide the needed changes. It is imperative that they tackle the issue of spatial organization, and its counterpart transport. Spatial organization influences energy consumption, through commuting trips and goods' transportation. Besides, the transport sector appears to be the most dependent and vulnerable of all sectors to rises in the price of oil and potential fuel shortages. In order for European countries to ensure a transition towards the post-petroleum age, it is thus necessary to assess the role of urban land use as a driver of energy – and specifically oil – consumption. Our study focuses on France, whose transport sector is highly dependent on oil importations.

Method

To study the relationships between the spatial patterns at the urban and regional scale and the oil market, we build a model that can be incorporated in a Computable General Equilibrium (CGE) framework for climate policy analysis. This model disaggregates national economies into a rural area and multiple interrelated urban agglomerations. Inter-city exchanges are twofold: goods and services are traded and migrations of both firms and households occur. In line with the New Economic Geography and Urban Economics, our approach considered as benefits the economies of agglomeration that arise from economic agents, both firms and households, being located close together. Producers have access to a large market (backward linkage) and enjoy knowledge spillovers, while workers benefit from numerous available product varieties and a thick labor market. On the other hand, external costs are reflected in the diseconomies that arise from congestion. Workers bear increased land and higher commuting costs, and firms have to pay larger salaries to compensate workers for the costs of living in urban areas. The model is dynamic as firms decide to locate where their profits are the highest and they can thus migrate to alternative locations. Firm migrations in turn lead to population displacements, as workers are looking for places where they can find jobs. Firms are supposed to migrate much slower than households, which react instantaneously to new job locations.

In order to study the links between spatial patterns of the economy considered and global oil markets, the model described above is coupled with a CGE modeling framework. CGE models are being increasingly used by research institutes and international organizations as numerical instruments that are capable of providing policy makers with a wide range of information on several economic sectors. Standard CGE models adopted in environmental economic analyses are based on multi-regional, multi-sectoral analytical frameworks. They capture the economic efficiency of policy measures (mainly, carbon taxes/subsidies and emission trading permits) aimed at CO_2 abatements as well as the distributional effects they entail. They can in fact provide numerical outcomes under different policy scenarios, simulating what economic impacts arise from specific policy interventions. In consequence of the cost (benefit) pressure exercised on its sectors by a tax (subsidy), the economy reacts by adjusting production and consumption, as well as reallocating input factors according to prefixed factors of substitutability. Most empirical CGE models are static models. However, a dynamic framework is essential when studying the role of spatial organization on the dependence of the transport sector on fossil fuels as it is characterized by strong inertias.

The exercise of embedding urban economies in a Computable General Equilibrium framework is realized in the French context under different forecasting scenarios. These scenarios were built with the aim of revealing the conditions for a successful transition of the French economy towards the post-petroleum age. They differ from each other by the macro energy context and by the urban dynamics considered. At the macro energy level, some hypotheses are made regarding the price of oil, the availability of alternative fuels, and the magnitude of

technological change. With respect to the spatial dynamics, different public policies are assessed, in particular infrastructure policies. Two axes are defined which vary from uptight to lose to define the macro energy context (mostly captured by the oil price) and from low to significant to capture the nature of the policies implemented regarding infrastructure. Four scenarios are thus defined and assessed in this study.

Results

Rises in the price of oil will have profound implications for transport. Indeed, the transport sector is currently utterly dependent upon conventional oil and cannot restructure or alter its technologies overnight. Within and between cities, private road transport underpins transport energy use. Alternative transport means, as public transport and rail, need to be further promoted and the whole energy demand related to the transport sector to be reduced.

The role of spatial organization appears to be essential. The location of economic activities affects the use of each transport mode, and the price of transport impacts the migrations of firms. Under scenarios with important energy constraints, urban agglomerations tend to both be less dependent on oil-based transportation and to limit their exchanges between each other. But cities can lock-in to fossil fuel intensive trajectories, when they do not provide alternative transportation means. A higher dependence on oil fuels will thus lead to a net loss of growth.

A better distribution of economic activities across the country can be eased through infrastructure investments, and thus can limit the oil dependence and prevent growth loss. The development of effective public transport networks within cities and of reliable railways between agglomerations should be prioritized. Besides, construction of dwellings can lead to a reduction in commuting distances and lower the rents. These infrastructure investments have to be implemented depending on the size of urban agglomerations. The development of smaller cities, where congestion costs are low and commuting distances are short, enables to weaken the dependence to oil.

It is important to note that the construction of transport networks and new dwellings may take time, while the oil price may be uncertain, as seen during the last decades. Infrastructure investment policies thus have to be implemented quickly in order to cope with the inertias of urban systems. Other policies that develop alternative energies and limit fossil fuel demand obviously have to be encouraged at the same time. Technological changes in vehicles and fuels can occur in parallel with such broader urban systems changes and will be much more effective in the context of greatly reduced travel demand for private transport.

Conclusions

This study indicates that the spatial dimension of the economy matters in the energy security and oil scarcity debates. It differs from earlier work, which focused on a global aggregated approach, by introducing production, consumption, trade and urban-related external costs for multiple cities within regions. Our study represents regional economies where multiple urban agglomerations dynamically evolve and alternative configurations of city growth potentially emerge. This is done in a simple analytical framework that enables to account for external (costs) benefits of land use and transport that reflect the (dis)economies arising from agglomeration.

The relationships between urban, regional and global economies should be considered as a means to offset the cost of oil price rises, and national government may resort to urban infrastructure to reach this purpose. Both the modeling arguments and the simulations indicate that setting infrastructure policies for the control of long-run development patterns of cities is a beneficial strategy to curtail national dependence on fossil energy.

In sum, the results of this integrated modeling analysis of spatial economy have emphasized that while energy security and oil scarcity are global externalities, local stakeholders can be influential. The inherent difficulties involved in planning over a forty years horizon may be eased by integrating the regional and urban dimensions of energy policies.

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