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Research paper

A spatial-explicit price impact analysis of increased biofuel production on forest feedstock markets: A scenario analysis for Sweden

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ABSTRACT

The present paper introduces an integrated spatially explicit framework for assessing price impact on forestry markets in Sweden. The framework is based on the "soft-link" of a price determination model, the SpPDM model with the BeWhere Sweden model. The aim is to analyse the impacts of increased forest-based biofuel production for transportation within the Swedish context by 2030. To that effect, we develop scenarios analyses based on the simulations of successive biofuel production targets, under different assumptions concerning the competition intensity for forest biomass and the use of industrial by-products. The results suggest marginal impacts on the prices of forest biomass. The average across spatial-explicit prices varies from 0% to 2.8% across feedstocks and scenario types. However, the distribution of the spatial-explicit price impacts displays large variation, with price impacts reaching as high as 8.5%. We find that the pattern of spatial distribution of price impacts follows relatively well the spatial distribution of demand pressure. However, locations with the highest price impacts show a tendency of mismatch with the locations of the highest demand pressure (e.g. sawlogs). This is a counterintuitive conclusion compared to results from non-spatial economic models. The spatial-explicit structure of the framework developed, and its refined scale allows such results to be reported. Hence, from a policy-making perspective, careful analysis should be devoted to the locational linkages for forestry markets of increased biofuel production in Sweden.

1. Introduction

In recent decades, the transition from a fossil fuel-based economy to a biobased economy has gained much traction in policy circles and in the research community. This has been motivated by a number of interlinked issues such as reduction of greenhouse gas emissions, energy security and independence as well as renewable energy targets. In this transition, forest resources have an increasingly important role to play. The expected increase of the demand for forest resources will have a direct impact on the forestry sector and on its utilization of forest resources. For instance, it will affect market prices, profitability, rural employment, recreation and forest ecology. The transition will also create opportunities to develop, and invest in, new or improved value chains using forest resources, such as biorefineries [1]. Specifically, it is thus important to understand how the expected increase in the demand for forest product will affect its price level and competitive situation. Moreover, since forest resources typically are bulky and spatially distributed over large areas, their utilization are often associated with high transportation costs. This suggests that possible price and allocation effects from a demand increase are local (or regional) in its character. Thus, an appropriate analysis needs a spatial dimension. The purpose of this paper is to assess spatially the implications on the forest markets, in terms of changing prices and allocation patterns, from an introduction of large-scale production of transportation biofuel using forest biomass as feedstock.

An integrated model approach is developed and applied on Sweden. Sweden is a good case study since it is a pioneer in terms of early adoption of renewable energy, especially bioenergy, and is relatively well endowed with forest resources. For example, the share (level) of biomass of total energy supply has increased from 11% in 1983 (52 TWh) to 25% in 2015 (134 TWh) [2]. It has also been suggested that the annual bioenergy demand might increase by 40 TWh in 2030 and by

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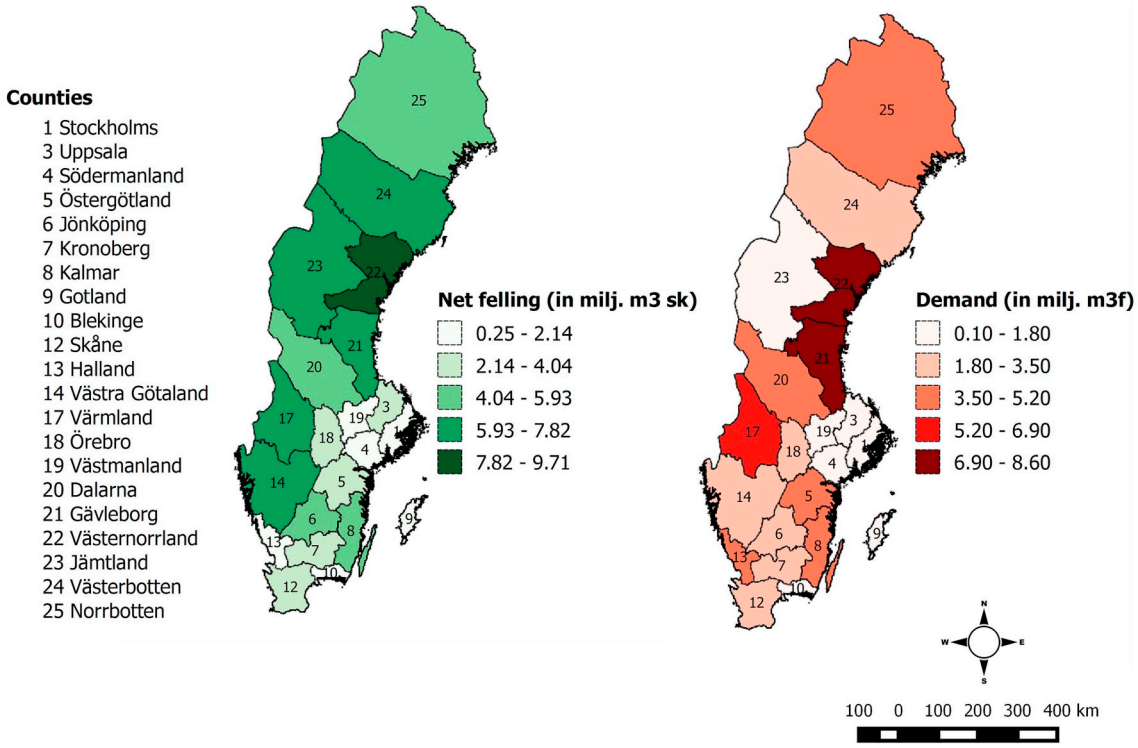

Fig. 1. County-level spatial distribution of 3-year average net felling (in million m^3 standing volume, m^3sk, for the period 2014–2016) and current demand[1] (in million m^3 solid, m^3f).
Data source: https://www.skogsstyrelsen.se/statistik/statistikdatabas/ *(Last accessed 1/18/2018)*

over 60 TWh in 2050, taking into account demand for industrial use, heat and electricity generation, and as feedstock in the production of transport biofuels and chemicals [3–6]. However, large parts of the projected demand increase originates from new supply chains (fully or partly) that currently do not exist in Sweden.

In terms of industrial consumption of forest resources, the pulp and paper industry together with the sawmill industry account, on average, for almost the entire roundwood consumption (roughly equally divided between them). Only 8% of the harvested roundwood is used for other purposes [7]. Moreover, the net felling of roundwood in 2016 amounted to 74.8 million m^3 solid, of which 47% was sawlogs, 43% was pulpwood and approximately 10% was fuelwood [8]. Fig. 1 illustrates the spatial distribution of the net felling. As we can observe, net felling volumes availability is lower in the southern regions of Sweden, especially along the coastal lines; whereas in the northern regions, availability is high in volumes terms, especially in the mid-northern regions.

Recent empirical literature has focused primarily on model development characterized by system approaches to the analysis of value chains. The focus of such models spans a number of themes that covers issues related to procurement costs of forest feedstocks, transportation logistics, optimal localization of biorefineries, etc. [9–11]. Another development in the literature is the explicit treatment of the spatial dimension. To this effect, most modelling efforts used geographical information system (GIS)-based models that explicitly account for the spatial dimension [12–17], and/or a hybrid approach that uses a techno-economic routine of cost-minimization of the whole value-chain, all the while incorporating the spatial dimension explicitly [11,18–23]. In Sweden, a number of studies have been carried out, which focused primarily on a spatially-explicit harvest cost model and/or hybrid models as discussed above [24–26]. However, most studies lack any feedback to forestry markets. Hence, the main objective of the paper is to introduce explicitly feedback-links to forestry markets in the context of highly disaggregated spatial models for forest value-chain optimization. We first test our modelling strategy within the Swedish context. The main contribution of our modelling framework lies in the ability to map out the distributions of price impacts at very refined spatial scales, which would provide valuable insights about their heterogeneous nature based on the scenarios adopted for supply availability, demand pressure, etc.

We organize the paper as follows. In Section 2, we discuss the scenarios adopted in the analysis, with a detailed description of key data inputs. In Section 3, we extend the discussion to the analytical framework adopted in the analysis by discussing model structure and integration. In Section 4, we present the results of the simulations and analyse the key factors driving them. We conclude in Section 5 with key findings and potential areas of further investigation.

2. Data and materials

Currently, bioenergy features prominently in Swedish energy and environmental policy-making and represents a cornerstone in the long-term strategy of decoupling the economy from fossil fuels and achieving greenhouse gas emissions reduction targets [27]. Forest-based biomass is the major source of feedstocks in the biofuel production in Sweden owing to its rich forest endowments.

For the spatial assessment the price impact and changing allocation patterns on forest feedstocks from an introduction of large-scale production of transportation biofuel, a set of plausible future scenarios need to be outlined. The scenarios included in the analysis represent the projected demand schedule for forest feedstocks in Sweden under incremental biofuel production targets by 2030. The scenarios are constructed based on a combination of different assumptions about biofuel production targets, demand from the forest industries and the use of by-

[1] The current demand is obtained from the BeWhere Sweden model for the business-as-usual (BAU) scenario, which represent current use of forest biomass across sectors (possible to add reference to this run?).