Extended Abstract
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Paper/Poster Title	**Cost-effectiveness of economic policy for agricultural bioenergy.**

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Abstract	***200 words max***
Sweden aims for climate neutrality by 2045 and a fossil-independent vehicle fleet by 2030. Agriculture is a key sector for climate change mitigation: potential has been identified not only for emissions reduction in food production and consumption, but also for contributing to society-wide emissions reduction through increased supply of bioenergy feedstock. Cultivation of second-generation energy crops is currently limited in Sweden, but expansion of the industry could be accelerated through policy intervention. This study uses agent-based and integrated assessment modelling to compare subsidies to production of second-generation energy crops, using the county of Jönköping, Sweden, as a case. We find a 25% higher cost-effectiveness (kWh euro^{-1}) from a feed-in tariff compared to a hectare subsidy, but also variations along a gradient of production targets. Important conflicts exist between bioenergy production and other societal goals, notably food security and maintaining biodiversity and ecosystem services in agricultural landscapes. Less productive regions such as Jönköping are more sensitive to changes in relative profitability and large-scale land-use change is hence more likely, compared to more productive regions. However, land-use change could be beneficial if it results in greater landscape diversity than the status quo.	

Keywords	Agricultural policy, bioenergy, economic modelling
JEL Code	Agriculture: Agricultural Policy Q18

Introduction	***100 – 250 words***

With the climate crisis, the search for alternative non-fossil energy sources has turned attention to the potential of agriculture to supply feedstock to bioenergy production. Indeed, it has been predicted to be the main source of increases in biomass supply in the coming decades (Slade et al. 2014). The contribution of dedicated energy crops to bioenergy production in Sweden is currently small (Börjesson 2021), but increased energy crop production could be achieved through policy intervention.

The urgency of climate change mitigation arguably allows for some deviation from first-best policy choices in return for risk reduction. Direct agricultural subsidies as instruments for emissions reduction have low efficiency but may be desirable as temporary complements to broader instruments, supporting technological development and deployment in the bioenergy sector (Stern 2006). Area-based subsidies at farm level is the main instrument in the EU Common Agricultural Policy

framework today and hence a plausible and pragmatic instrument choice. But alternative instruments designs exist, and policymakers should not lose sight of cost-effectiveness as a central decision criterion.

This study makes two important contributions. The first is the expansion of the agent-based policy simulation model AgriPoliS with energy crop production activities, leading to considerably improved possibilities to analyse direct and indirect effects of policy and farm businesses' decision-making. Second, results are presented from simulations of two different economic policy instruments targeting energy crop production in Sweden. The cost-effectiveness of instruments for contribution of energy is compared, as well as consequences for agricultural production, farm income, land-use, and environmental impacts.

Methodology ***100 – 250 words***

We use the static version of AgriPoliS (AGRIcultural POLIcy Simulator) (Happe et al. 2006) to predict farmers' economic and strategic decisions in the county of Jönköping, Sweden. AgriPoliS is an agent-based model using a mixed-interger LP optimization approach. It is an economic model calibrated to empirical data on Swedish farm structure and production in four regions (only Jönköping is used in this phase). Model simulation output includes agricultural production, market activities, and effects on land-use; the latter are subsequently integrated with models for environmental effects. To permit the present analysis, AgriPoliS is expanded with new production activities for energy crops: short rotation coppice willow (SRCW), reed canary grass (RCG), and ley grass for biogas.

We run two policy scenarios introducing policy instruments promoting energy crop production: one hectare subsidy (area scenario) and one energy content subsidy (energy scenario). These are compared to each other and to a BAU scenario. The policy target is to achieve 0.6 TWh of bioenergy feedstock from agriculture in Jönköping.

Results ***100 – 250 words***

The cost of the hectare subsidy exceeds the cost of the energy content subsidy by 25 percent (12.5 million euro compared to 10 million euro). In the area scenario, nearly the entire target is filled by RCG production. RCG dominates in the energy scenario too, but SRC willow is also produced in this scenario which requires more productive land than RCG. A small amount of grass ley for biogas is produced in both policy scenarios.

Jönköping is a forested region dominated by cattle production and arable land is used for feed production. Compared to BAU, beef production declines sharply in both scenarios whereas dairy production increases slightly. Sheep production also declines, but less than beef. Production of silage is halved and replaced by energy crop production. Land set aside in BAU is fully reintegrated into production.

Energy crops are grown on arable land only, hence semi-natural pasture remains intact and in use (sheep production) in both policy scenarios.

Discussion and Conclusion	*100 – 250 words*

Production subsidies can cause major substitution effects, particularly in regions with lower productivity. Industries with lower profitability are more likely to be affected than more profitable industries.

Increased energy crop production will lead to land-use change, accompanied by complex environmental and economic implications. Conflicts with other societal goals may occur, notably safeguarding domestic food production and maintaining biodiversity and ensuing ecosystem services in agricultural landscapes. This entails potentially substantial trade-offs that must be anticipated and studied *ex ante*.

Infrastructure and markets for agricultural bioenergy feedstock are far from mature in Sweden. The responsiveness of the agricultural sector and consequences for land-use are hence highly dependent on future development, not least market prices and pattern of growth in the sector, particularly distance from farm to bioenergy production facility.

Cost-effective increase in energy crop production does not automatically lead to a replacement of fossil fuels, emissions reduction, or climate change mitigation. They may however still be desirable as a complement to consumption-side instruments, supporting technological development and deployment temporarily.

In a forthcoming publication our scope is increased and will include three more agricultural regions in AgriPoliS, that together are representative of the Swedish agricultural sector. This provides variation in agricultural, environmental, and socio-economic conditions and makes our findings relevant to the contexts of other EU member states. Short rotation forestry poplar will also be introduced.

Börjesson, P. 2021. *Potential för ökad tillförsel av inhemsk biomassa i en växande svensk bioekonomi – en uppdatering,* Lund University, Division of Environmental and Energy Systems Studies.

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