An economic assessment of swarm robotics for field crops

Population and economic growth is driving up the demand for more and better quality food, especially fruits and vegetables. Simultaneously, there is pressure to limit the environmental footprint of agriculture, manage existing land more intensely, use fewer inputs and apply those inputs only when and where they are most needed. Managing farms more intensely usually requires more workers, but in the UK and many other parts of the world agricultural labour is increasingly difficult to hire. Agricultural automation and robotics are often suggested as part of the sustainable intensification solution. Automating routine agricultural operations would reduce the labour constraint. Robots might make it economically feasible to manage individual plants and animals, instead of managing fields and herds. With robots and automation is might be possible to microdose fertilizers and pesticides.

The technical ability to automate routine farm work and to enable autonomous agricultural robots is rapidly developing. Unfortunately, the economic and social implications of this technology are less well known. A recent review of economics of agricultural robotics studies found only 18 studies worldwide of which 14 were simple partial budget analyses that looked at automating a single farm operation (e.g. weeding, harvesting). Only three studies made a preliminary consideration of the systematic changes that could be triggered by automating farming activities.

The recent review of literature suggests that the main constraint to economic analysis of field crop automation is the lack of information on economic parameters (e.g. field times, yields, costs). Field robotics are new and worldwide there is little experience with the technology. The Hands Free Hectare (HFH) experience at Harper Adams University in 2017 and 2018 (http://www.handsfreehectare.com/) can provide initial estimates of those economic parameters for swarm robotics. Information will be sought from manufacturers on automation of large conventional equipment (e.g. http://www.smart-ag.com/). The objective of this assessment would be to estimate the potential benefit of autonomous production of grain and oilseeds in the UK at the per hectare, farm and national level.

The methodology will have three steps:

1) Data collection – Crop budgets for the assessment will be built on the existing information in the John Nix Pocketbook and The Agricultural Budgeting and Costing Book supplemented with information from cooperating farms, crop consultants, agronomists/horticulturalists, manufacturers and engineers. Field time, cost and other parameters for swarm robotics will be estimated based on the HFH experience at Harper Adams University in 2017 and 2018.
2) Development of crop budgets for likely cropping alternatives. Budgets for all crops will be specified with both conventional mechanization or automated vehicles. Major cropping alternatives for UK farms will be considered including root crops (i.e. potatoes, sugar beets, carrots) and pasture rotations. The initial analysis might be either conventional or organic management. The budgets will provide an initial per hectare comparison of conventional, automated large equipment and swarm robotic production systems.
3) A farm linear programming (LP) analysis to identify potential systematic effects of robotics. The LP analysis will use the General Algebraic Modeling System (GAMS – www.garms.com). It will build on the simplified farm LP model using GAMS developed for assessment of crop and livestock alternatives in the Orinoquia region of Colombia in 2017 (https://www.purdue.edu/colombia/partnerships/orinoquia/). For the non-specialist LP can be thought of as automated budgeting that facilitates the systematic comparison of budgets for hundreds or thousands of alternatives. The

farm level analysis will be aggregated to the national level with the currently number of farms producing the target crop and with sensitivity testing around changes in import/export of that crop product.

The outputs from this assessment will be:

A) Detailed budgets for current-state-of-the-art autonomous/robotic crop production systems.
B) A per hectare comparison of cost from conventional and robotic crop production systems.
C) A farm level analysis of crop and technology choice that identifies under what circumstances robotic production is economical.
D) A nationwide assessment of the potential impact of automation of the chosen crop in terms of farm profitability, labour use and overall contribution to GDP. The analysis will include a sensitivity test on how the level of imports/exports might change with automation.

At Harper Adams University, the study will be supervised by Prof. James Lowenberg-DeBoer. Lowenberg-DeBoer is an agricultural economist with 30+ years of experience in the economic assessment of new technology for agriculture.