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Offshoring insect farms may jeopardize Europe's food sovereignty

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Commentary

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Abstract

Non-technical summary. Given increasing global political, security and economic challenges, politicians in the European Union (EU) are seeking to reduce the EU's dependence on imports, including feed for farmed livestock. While insect farming has been suggested as an advantageous source of livestock feed is the insect farming industry, the sector has not met optimistic expectations. In particular, labor and electricity costs are driving insect companies offshore, including to Asia and the United States. This paper explores ways that the EU could solve this problem, the most promising of which is to expand the EU's production of maize and soy.

Technical summary. In the context of the Russian invasion of Ukraine and increasing global destabilization, policy makers within the European Union have expressed the need to reduce the bloc's dependence on imported agricultural products such as livestock feed. One industry that has been promoted as an advantageous source of livestock feed is insect agriculture. However, the insect industry's growth has not kept pace with optimistic expectations, and high labor and electricity costs in Europe appear to be driving major insect companies to expand production offshore. One solution may involve supporting the automation of insect farming, though automation may have harmful social consequences by reducing employment and exacerbating inequality. A more promising solution could involve bringing additional land under cultivation to expand domestic production of maize and soy, and the most up-to-date estimates suggest that doing so may even offer environmental benefits over insect production.

Social media summary. Insect farming has been offered as a solution to EU food security, but labor and power costs complicate the picture.

1. Introduction

In recent years, few topics have generated as much academic interest and popular optimism as insect farming. Proponents of insect farming have drawn attention to ways that insect production could benefit environmental sustainability, food system resilience, and local producers (IPIFF, 2023). These benefits, together with the potential for significant economic returns, have drawn venture capital and research effort to support the nascent insect farming industry (Halloran et al., 2018; Rabobank, 2021).

However, to deliver any benefits, the insect production industry still has substantial barriers to overcome. These include logistical challenges, food safety concerns, the disposal of frass (insect waste), and competition with conventional livestock farming for key inputs such as high-quality feed (Grasso & Bordiga, 2023; Smetana, 2023; Thrastardottir et al., 2021).

While insects farmed for human consumption have attracted headlines, insect production in the Global North is almost entirely used to produce animal food and feed. The market share of insects farmed for human consumption is 'negligible', according to a recent Rabobank report (Rabobank, 2021). Rather, almost all insects in Europe and North America are farmed to produce feed for pets, farmed fish, and farmed poultry (Halloran et al., 2018). The main insects farmed for feed are larvae of three species: black soldier flies (*Hermetia illucens*), yellow mealworms (*Tenebrio molitor*), and house flies (*Musca domestica*) (Grasso & Bordiga, 2023; Halloran et al., 2018).

In the European Union (EU), narratives around the sustainability and social implications of insect farming need to be understood in the context of the EU's food strategies and emerging geopolitical crises. The key document outlining the EU's objectives is the farm to fork strategy, which aims to ensure that the food system is having a positive impact on the environment, food security, public health, and economic returns.

The EU's agricultural strategy can be situated in the context of global trends. While humanity is capable of feeding itself, transformations are needed to ensure that food production is inclusive and sustainable (Vos & Bellù, 2019). The EU sees itself as a major contributor to food security, sustainability, and justice around the world (Maggio et al., 2016). The Commission's 2022 communication made frequent reference to global food security, food assistance, and support to countries in need, and 'the transition towards sustainable, resilient and fair food systems in the EU and globally' (European Commission, 2022). The EU can indeed exercise power over the direction of the global food system. Such power can be exercised directly, through the EU's own agricultural production and provision of food aid, or indirectly, by setting standards and regulations that are subsequently adopted by producers and governments in other countries (the 'Brussels effect') (Bradford, 2020; Maggio et al., 2016). Therefore, the EU's policy response to any agricultural issue – including insect production – will need to pay attention to the EU's role in the global community and its stated desire to improve sustainability and social justice around the world.

More urgently, the attention of the EU's policy makers has been drawn by the geopolitical and humanitarian crisis that is the Russian invasion of Ukraine. Beyond the immense human suffering, the war is also shining a light on fractures in the EU's food systems. These fractures have motivated the EU's policy makers and institutions to identify areas where the bloc can improve its food self-sufficiency. French President Emmanuel Macron expressed this view concisely, as reported by *Politico* (Wax, 2022): 'We can no longer depend on others to feed ourselves'.

A communication from the European Commission emphasized that while the EU is actually self-sufficient in most of its food, it is not self-sufficient in key inputs into its food production (European Commission, 2022). This is something of a paradox; while the EU is largely self-sufficient in food outputs, the EU relies heavily on imports for animal feed, including soybean and maize, and energy. As such, the EU has begun to pursue policies to improve its self-sufficiency in these essential inputs (European Commission, 2022).

To progress the policy goal of food self-sufficiency, the EU established a 'Contingency plan for ensuring food supply and food security in times of crisis'. As part of this, the EU also established the European Food Security Crisis Preparedness and Response Mechanism (EFSCM), a group of Member State representatives, stakeholder organizations, and other experts, to support coordination across sectors and Member States (Bertolozzi-Caredio et al., 2023; European Commission, 2024).

Under the contingency plan and the EFSCM, there has been a large amount of resources invested into mapping the EU's agricultural supply chain, identifying weaknesses, and addressing those weaknesses with policy solutions (Bertolozzi-Caredio et al., 2023; European Commission, 2024; Loi et al., 2024). One such study concluded that the most significant risk to the EU's food self-sufficiency is the high costs and low availability of inputs, including energy and feed for livestock and aquaculture (Bertolozzi-Caredio et al., 2023). In particular, the livestock and aquaculture sectors depend on imported feed ingredients, such as soymeal (Loi et al., 2024). This pursuit of self-sufficiency in the EU may pose a challenge when considered alongside current trends in the insect farming industry.

2. The sluggish start of the insect industry

So far, insect production has not kept pace with optimistic projections. In 2019, the industry body International Platform of Insects for Food and Feed (IPIFF) projected that the annual production of all insect proteins (including for human consumption) would reach 1 million tonnes by 2025 and 3 million tonnes by 2030 (IPIFF, 2019). This projection was widely cited by both academic studies and news articles (Thrastardottir et al., 2021). In contrast, IPIFF's members produced around 9,500 tonnes of insect feed products in 2022 (IPIFF, 2023). Even accounting for insects produced for human consumption (currently a negligible market share (Rabobank, 2021)) and producers that are not members of IPIFF, it is difficult to see how the insect farming industry would achieve the 100-fold growth required to reach 1 million tonnes by next year. The online forecasting aggregation platform Metaculus currently predicts that 47,000 tonnes of insect protein will be used as feed in Europe in 2028 (Metaculus, 2024). This more modest prediction, which still expects the insect farming industry to expand by several times over the next few years, is only a couple of percent of the IPIFF's original prediction for 2030.

There are many factors contributing to the insect industry's struggle to meet expectations, including regulatory hurdles and unresolved logistical challenges (Grasso & Bordiga, 2023). However, one important observation is that many small-scale startups are struggling to scale up their production to a commercial level. There is a high turnover; the majority of insect producers wind down or go bankrupt within five years (Larouche et al., 2023; Thrastardottir et al., 2021). There appear to be some underlying economic dynamics that are preventing startups from expanding and reaching commercial production volumes.

3. Europe's insect farms are moving offshore

Offshoring occurs when production is fragmented into separate production processes carried out by different companies in different countries (whether or not those companies have the same owner). Offshoring is a result of the integration of the global economy. The past decades have seen a growing importance of offshoring in the EU in particular (Radło, 2017).

Likewise, we may be witnessing the beginning of offshoring in the EU's insect agriculture industry. Europe's biggest insect companies have recently announced plans to expand production outside of Europe (Figure 1). France-based Ÿnsect has announced deals with Jord Producers and Ardent Meals to expand insect production in the Midwest of the United States, and Ÿnsect has also announced a deal with Mexico City-based Corporativo Kosmos to expand production in Mexico. Meanwhile, Netherlands-based Protix and France-based InnovaFeed likewise have plans to expand into the United States. InnovaFeed has also announced plans to expand into South-East Asia (Roussange, 2022; Ÿnsect, 2022).

The decision to move insect production outside of the EU may be driven by the economic realities of insect agriculture. The financial details of insect farming operations are often kept secret, but we can glean some information from the seminal economic studies on the finances of this industry (Halloran et al., 2018; Niyonsaba et al., 2023a; 2023b; Thrastardottir et al., 2021).

Two major cost components in insect production are labor and energy. To date, the only study to provide empirical evidence on the finances of insect farms in Europe is a study of seven *T. molitor* farms in the Netherlands. In this study, labor emerged as one of the biggest cost components, ranging between 677 and 2913 EUR/tonne production when the farmer's own labor was included (Niyonsaba et al., 2023a). Labor costs were exceeded on some farms only by the major upfront investments for buildings and machinery. Manual labor is required when caring for larvae (e.g. moving eggs into crates, feeding larvae, harvesting larvae, cleaning crates, and replacing beetles) and for other on-farm processes,

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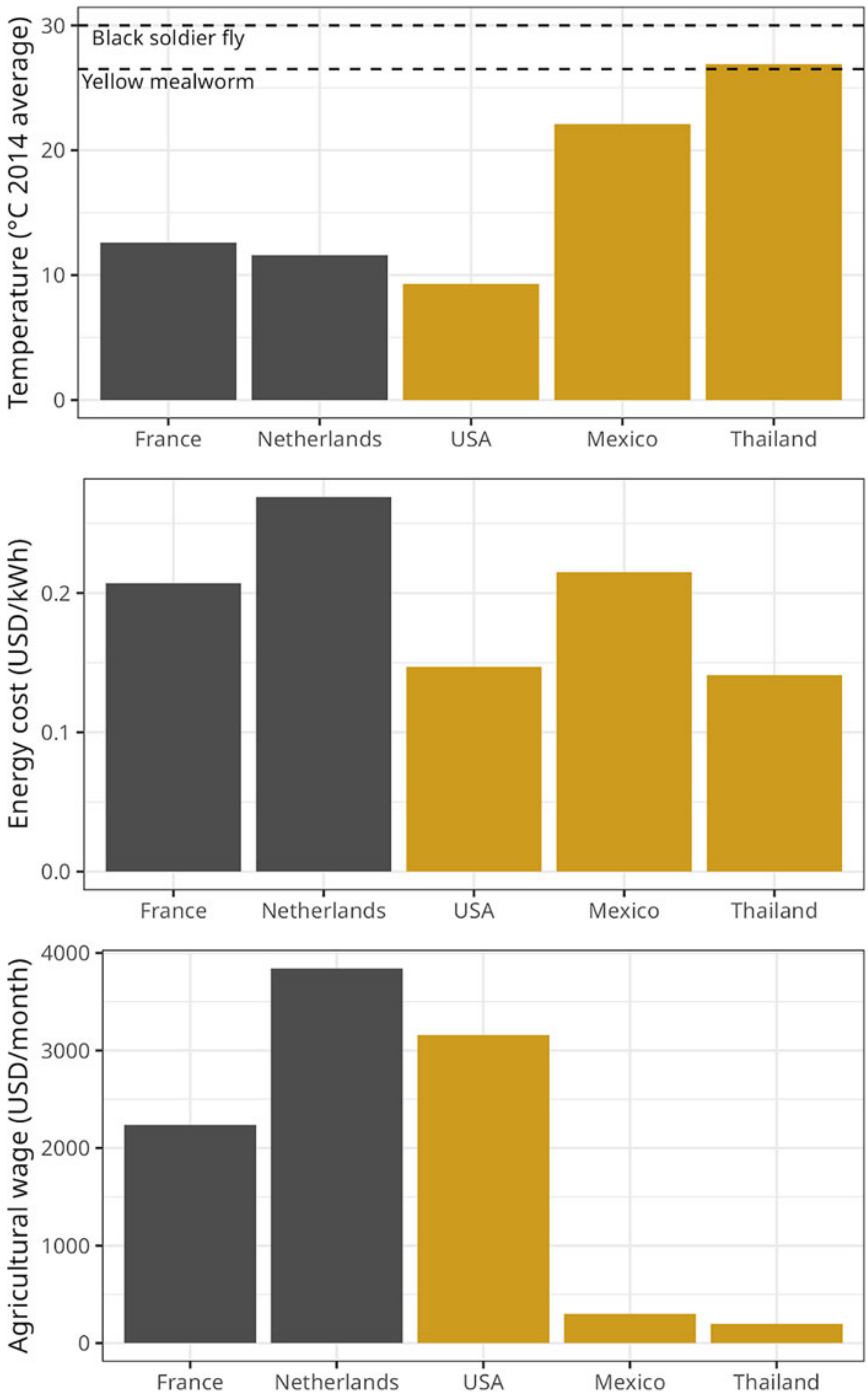

Figure 1. Offshoring of European insect production may be driven by Europe's higher costs for energy and agricultural wages. Insect production requires specific temperatures (top), electricity (middle), and manual labor (bottom), which are cheaper to obtain in North America and South-East Asia. The dashed lines in the top graph represent approximate optimal temperatures for rearing larvae of black soldier flies and yellow mealworms. Data: Climatic Research Unit, University of East Anglia (crudata.uea.ac.uk, ODbL 1.0 licence); Global Petrol Prices (globalpetrolprices.com, CC BY-NC-ND 3.0 licence), International Labour Organization (ilostat.ilo.org, CC BY 4.0 licence).

such as administration, transport, and marketing (Grasso & Bordiga, 2023; Niyonsaba et al., 2023a). Given the high costs of labor, insect industry stakeholders have identified high labor costs and low levels of automation as main barriers to the expansion of insect production (Niyonsaba et al., 2023b). Therefore, in developed countries, the profits of insect production may only exceed that of conventional animal protein sources when insect farms reduce wage costs by becoming highly automated (Halloran et al., 2018).

When it comes to energy, there are several on-farm processes that contribute to farms' electricity demands. The temperature and humidity level needs to be maintained within a relatively narrow range. Suitable temperatures tend to be relatively high (27–40 °C, depending on species) (Grasso & Bordiga, 2023). Electricity is also needed for slaughtering insects, which may involve energy-intensive processes such as freezing, oven baking, or blending; processing dead insects; and storing substrates and other perishable products (Grasso & Bordiga, 2023). Furthermore, for farms that invest in automation, we can expect the costs of electricity to increase accordingly.

Critically, labor and electricity tend to cost more in Europe than in other insect-producing regions (Figure 2). Consider the

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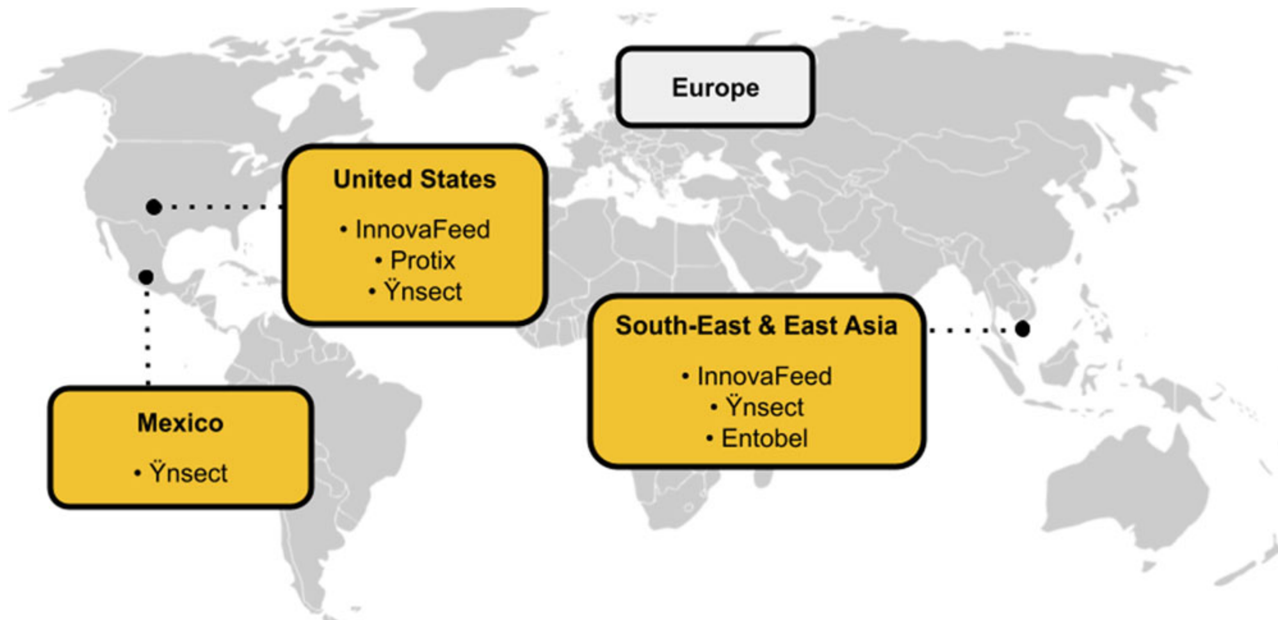

Figure 2. The largest European insect farmers are expanding overseas. Key destinations include the United States, Mexico, and South-East Asia (Roussange, 2022; Watson, 2023; Ynsect, 2022).

labor costs of 677 to 2913 EUR per tonne production, reported for *T. molitor* farms in the Netherlands (Niyonsaba et al., 2023a). These costs suggest that a move from the Netherlands (with labor costs of 3841 USD per month for agricultural work; Figure 2) to, say, Thailand (198 USD per hour) could save a producer between 642 and 2762 EUR in labor costs for every tonne of production (91%). Of course, this is a simplified calculation, but it illustrates the important fact that insect producers can save lots of money for every tonne of production by moving to countries where labor – often producers' largest cost component – is cheaper.

Moreover, the higher temperatures in many insect-producing South-East Asian countries would reduce the difference between the ambient air temperature and the optimal temperature for insect growth, thereby reducing the electricity required by insect farms in the first place. One study on mealworms farmed by the company Ÿnsect in France found that producing 1 kg of fresh insects uses 1.152 kWh at farm gate and 8.940 kWh at processing plant gate (Thévenot et al., 2018). In France, with energy costs of 0.136 USD per kWh in 2019, 1 tonne of fresh insects would thus cost the producer 157 USD (at farm gate) or 1216 USD (at processing plant gate) in energy costs alone. Much of this cost comes from maintaining the rearing room at 28 °C in a country where ambient temperatures average around 10 °C (mean for Lille, France from 2009 to 2013; Figure 2) (Thévenot et al., 2018). In contrast, ambient temperatures in Vũng Tàu, Vietnam, and Bangalore, India are 28.1 and 25.8 °C, respectively (Figure 2). As such, production in Vietnam or India rather than Western Europe enables the producer to avoid this substantial cost component. The United States does not necessarily have a warmer climate, but that country does have cheaper electricity and would therefore still represent a cost saving for producers (Figure 2).

The economic reality of labor and energy costs, and the resulting incentive to move insect production offshore, is a topic about which stakeholders within the insect industry are candid. The investor Tan Shao Ming, when discussing his support for Innovafeed's plans to expand in Southeast Asia, reports (ABC Impact, 2022): 'We believe that there is a huge potential for Innovafeed's technology and platform to be rolled out in Southeast Asia, given the tropical climate which is conducive for the black soldier fly'. Alexandre de Caters, the Belgian co-founder of insect company Entobel, gives a similar reason when explaining his choice to base his company in Vietnam (Watson, 2023): 'It quickly became obvious that Europe was not the place to start for the simple reason that black soldier flies are tropical insects. […] We plan to grow further inside Vietnam, but the bigger facilities would likely be outside Vietnam in countries with tropical weather and a stable supply of feedstock such as Indonesia and Malaysia'. And Ankit Alok Bagaria, CEO of India-based company Loopworm that aims to produce insect-based aquaculture feed, emphasizes the role of both labor and energy costs (Fletcher, 2023): 'In Europe the labour cost is very high and, as the climate is not so suitable for insect growth, [European producers] have to customise and modulate the climate in their farms'.

4. Discussion

If the EU's insect companies find the idea of moving offshore attractive, how could policy makers respond? Could the automation of the insect industry, as some companies are pursuing, improve the efficiency and sustainability of the EU's food production (Thrastardottir et al., 2021)?

4.1 Automation

While automation can reduce labor costs, it would also bring a series of trade-offs. First, automation would, by definition, reduce the ability of insect farms to contribute to employment (Heckmann et al., 2019). The irony is that local employment has been promoted by industry stakeholders as one potential benefit of insect farming in the first place (Grasso & Bordiga, 2023; IPIFF, 2023). Second, as mechanical and electrical energy is a major component of insect farms' energy use, automation may increase energy consumption (Kok, 2021). Third,

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automation could have different impacts on the demand for contrasting types of labor. While this is a complex debate, it is plausible that automation of agricultural production – in the strict sense of deliberately finding ways to reduce the need for human labor – could have a disproportionate impact on low-skilled labor and could exacerbate economic inequality (Krenz et al., 2021; Rijnks et al., 2022). One analysis of Dutch yellow mealworm farms found that producers often hire low-skilled laborers who 'have difficulties qualifying for a regular job' (Niyonsaba et al., 2023a). Therefore, automation of Europe's insect farms could disproportionately harm otherwise vulnerable agricultural workers. On the other hand, it is possible that automation could improve the efficiency of production, though this would hinge on how automation is applied in practice (Krenz et al., 2021; Rijnks et al., 2022).

In any case, we should be cautious about how food production technology can impact different members of society in different ways. Large, perhaps multinational, companies are more likely to have the capital and expertise to invest in automation than small, local startups (Thrastardottir et al., 2021). Automation may simply end up replicating the trend towards concentration of agricultural production in the hands of a few large companies – beyond the direct implications for social justice, this could increase popular suspicion of this new type of food production (Mohorcich & Reese, 2019; Piet, 2017). As such, while automation could indeed reduce high labor costs from the perspective of the industry, automation may create new problems for society that would render this policy response counterproductive.

It is unclear whether European consumers would accept livestock fed with insect-based feeds. One literature review drew an optimistic conclusion, finding that societal attitudes would not be a barrier to the use of insects as livestock feed (Sogari et al., 2019). In contrast, a recent qualitative study drew more nuanced conclusions, with participants expressing concerns about impacts on sustainability, pathogen transmission, and animal welfare (Bunker & Zscheischler, 2023). History provides the example of genetically modified foods; companies were confident in the environmental benefits that genetic modification could bring, and these companies were thus unprepared for popular backlash (Mohorcich & Reese, 2019). Popular fears and backlash may be exacerbated if production involves complicated technology and is controlled by a few large companies, and this is exactly the path that would be followed by an industry looking to automate production of a novel agricultural output (Amato et al., 2023; Mohorcich & Reese, 2019). As the popular backlash against genetically modified foods reveals, consumer education and communication are an important step in securing social approval (Mohorcich & Reese, 2019; Sogari et al., 2019). That said, investing in consumer education may be unattractive to investors, with a former insect company co-founder stating (Badeski, 2023): 'Spending venture equity dollars on an uphill battle to educate customers is not a good use of capital'.

4.2 Expanding domestic maize and soy production

A more feasible policy response may be to bring additional land into cultivation, thereby increasing domestic production of maize and soy (European Commission, 2022). At first glance, it might appear that insect production might offer environmental benefits over crop production. However, a detailed look at the underlying dynamics leads to a counter-intuitive conclusion.

Crop modelling reveals that there are large areas of central and eastern Europe that are feasible for soy production (Rotundo et al., 2024). Producing soy in the EU could reduce greenhouse gas emissions by reducing the production and transport of environmentally costly Brazilian soy (Rotundo et al., 2024; Schilling-Vacaflor & Gustafsson, 2024). Likewise, maize production appears to have a disproportionately low carbon footprint in Europe when compared to maize production around the world (Holka & Bieńkowski, 2020). Since this policy response would involve simply expanding production, rather than supporting an entirely new sector, this policy response may have higher public support.

In contrast, the environmental benefits of insect production may have been overstated (Biteau et al., 2024). The most up-to-date comparisons have found that producing compound animal feed using insects typically requires more energy and produces a larger carbon footprint than the production of animal feed using soy and grains (Smetana, 2023; Quang Tran et al., 2022). The promise of insect farms to deliver environmental benefits hinges on the ability to feed insects using food waste and to use insect waste to produce fertilizer. In practice, both of these ideas still face significant logistical, economic, and safety hurdles before they can be applied at industrial scales (Biteau et al., 2024). This is why large insect companies operating today overwhelmingly prefer the same high-quality inputs, including grains, that are already sought by other sectors (Biteau et al., 2024). When high-quality feeds are used as an input for insect production, this simply adds an additional trophic level to the food chain, thus increasing the overall environmental impact (Roffeis et al., 2020; Smetana, 2023).

For these reasons, bringing additional land under cultivation in the EU – which has been encouraged by the European Commission (2022) – appears to be a practicable and environmentally beneficial policy option.

4.3 The impact of climate change

It is worth mentioning how climate change may influence things. Higher average temperatures could slightly reduce the need for insect farmers to pay for heating costs, and Europe may see a modest decrease in electricity prices (Pilli-Sihvola et al., 2010; van Ruijven et al., 2019). On the other hand, positive impacts of climate change may be concentrated in the disproportionately wealthy areas of Europe, whereas less wealthy states in Southern Europe may see higher energy demand and electricity prices (Pilli-Sihvola et al., 2010; van Ruijven et al., 2019). Moreover, temperature increases will also be observed in North America and Asia, so offshoring production may remain equally attractive to insect producers as it is today.

It is plausible that widespread adoption of renewable energy sources could improve the picture for European insect production. There are concepts for insect farms that rely on side-stream heat or on-site renewable energy production (Smetana, 2023; Grasso & Bordiga 2023). However, such concepts are limited to small-scale production, and one life-cycle assessment concluded that 'it is unlikely that on-site renewables will be a solution for all insect producers' (Smetana et al., 2019). Also, switching to renewable energy sources would equally benefit other forms of feed production, so insect farming would not have a particular advantage in this regard (Paris et al., 2022).

To conclude, we can see that relying on insect production may result in the EU simply replacing soy and maize imports with insect protein imports, which could jeopardize the EU's pursuit of food self-sufficiency. In contrast, expanding domestic crop production may be the best policy solution for the EU to improve its agricultural self-sufficiency while preserving agricultural employment and public support.

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