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New Foods Produced with Genome-Editing Technique in the Global Marketplace

This *Cornhusker Economics* article builds upon a previous *Cornhusker Economics* article of September 8, 2021, on the heterogenous willingness to pay (WTP) for genome edited (GenEd) apples in France and the US (Beghin, 2022). Using graphical illustration, this new article summarizes in layman's terms two related economic analyses by Marette et al. (2022) and (2023). These analyses investigate Research and Development (R&D) investment in food innovations based on New Plant Engineering Techniques (NPETs), such as GenEd and traditional hybridization methods, and then in the context of international trade. With trade, innovators compete globally with their food novelties in each other's markets and in the rest of the world. Regulators in different countries may regulate these innovations and their use differently, affecting the scale of production and size of markets, hence the expected profitability of these innovations.

The approach combines uncertain and costly food innovation with consumers' WTP for the new food, and then the competition across borders with the possibility of heterogeneous regulations in different countries. The latter heterogeneity is a recurrent theme with biotechnology, known as "asynchronous approvals." Countries approve new genetic transformations in different ways and different time frames. Asynchronous approvals have vexed innovations based on Genetically Modified Organisms (GMOs) and their commercial success, especially in the European market. A redux of the GMO controversy could take place again with innovations based on NPETs although their safety is not in question. In 2018, the European Court of Justice ruled that NPETs were not equivalent to traditional hybridization (traditional mutagenesis) methods and should be considered as transgenic methods (like GMOs). The debate is currently unsettled in the EU and the European Commission is considering new regulation which would supersede the Court's decision and ease innovations based on NPETs.

The framework of Marette and co-authors is applied to the apple market. It relies on elicited WTP of French and US consumers for new improved apples. When consumers are less reluctant to adopt novelties based on NPETs, these investments and innovations are likely to be socially beneficial when the probability of success under NPETs is relatively high and the sunk cost of the R&D process is relatively low. The R&D process involves the cost of the science and associated regulatory costs. A transgenic-based regulation would imply a much longer process with added regulatory hurdles to be overcome. When consumers dislike NPETs and when the probability of success is low and/or the cost is high, these R&D investments are socially sub-optimal.

The framework integrates consumers' willingness to pay (WTP) for the novelty, the uncertainty and cost of R&D processes, the associated regulatory cost of approval, and the competition between domestic and foreign products. With generic applicability, the approach is relevant for the analysis of new foods that could be introduced in markets and then traded across borders. A hypothetical case of apples improved with NPETs is considered in the analysis calibrated on recent apple market information. Simulation results suggest that import bans and high values of sunk cost can reduce R&D investment in NPETs to suboptimal levels with reductions in global welfare. We will explain these next.

A main scenario in the analysis considers the US and the EU competing in the production of improved foods (apples in the calibrated application). Both countries can invest in R&D for improved apples using both hybrid or NPETs technologies and then produce improved foods NPETs and export such products worldwide. Worldwide is understood as the EU and US markets and an aggregate rest of the world (RoW), which does not innovate but regulates the use of NPETs-based novelties. The following figures show investment decisions by a social planner for different values of fixed investment in R&D and the probability of success with R&D, leading to innovation.

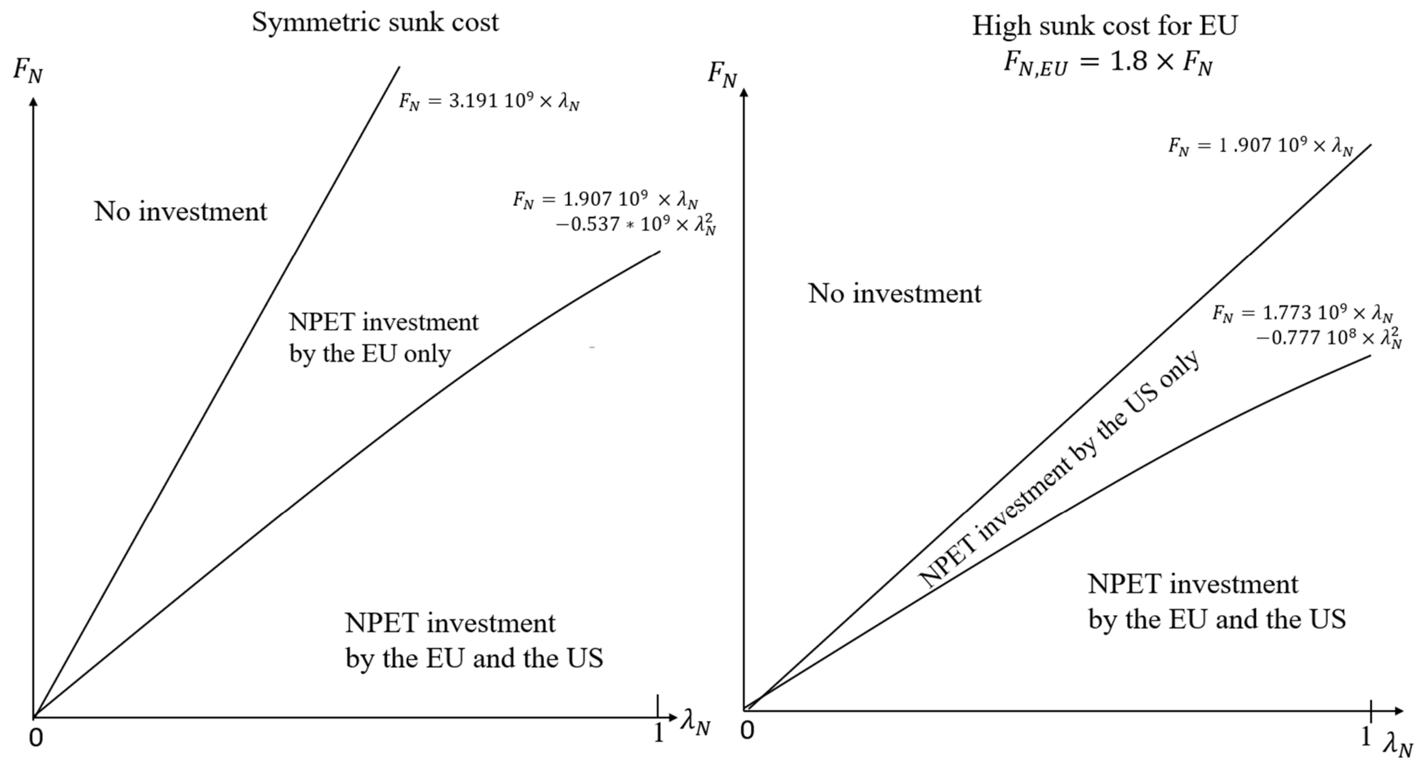
In Figure 1 below, the scenario assumes all three regions allow the consumption of improved foods generated with NPETs. Several variations of this scenario are analyzed in the publications. Here we focus on a central case. R&D investment decisions by the US and the EU are shown in the Figure. The vertical axis shows the sunk (fixed) cost of the R&D process (F_N) and the horizontal axis shows the probability of success of the R&D (l_N), leading to a market innovation. Symmetric sunk costs and probabilities of success in the US and in the EU are shown in the left panel of the Figure.

As shown in the left panel, R&D investment is optimal for both countries for relatively low levels of sunk cost. Still in the left quadrant, as the sunk cost increases and/or the probability of success decreases, the EU eventually emerges as the sole remaining investor in NPETs after the US leaves the space. The US exits first because the apple market in the EU is much larger than in the US and allows for local economies not attainable in the US to spread the innovation cost.

In the right panel, the EU R&D cost is assumed to be 80% higher in the EU while maintaining the same probability of success. This asymmetric cost case captures the potential high regulatory cost associated with the NPETS being considered as transgenic for example. Still, in the right-hand-side quadrant, the asymmetric cost structure between the EU and the US makes the EU exit first despite the scale advantage it has with its larger market.

Note that in both quadrants, the lowest frontier is quadratic in probabilities because two countries invest in NPETs, and the probability of success gets squared. The higher frontier(s) is (are) linear because a single country invests in NPETs. Equations shown in the figures come from the modeling exercise detailed in the two journal publications.

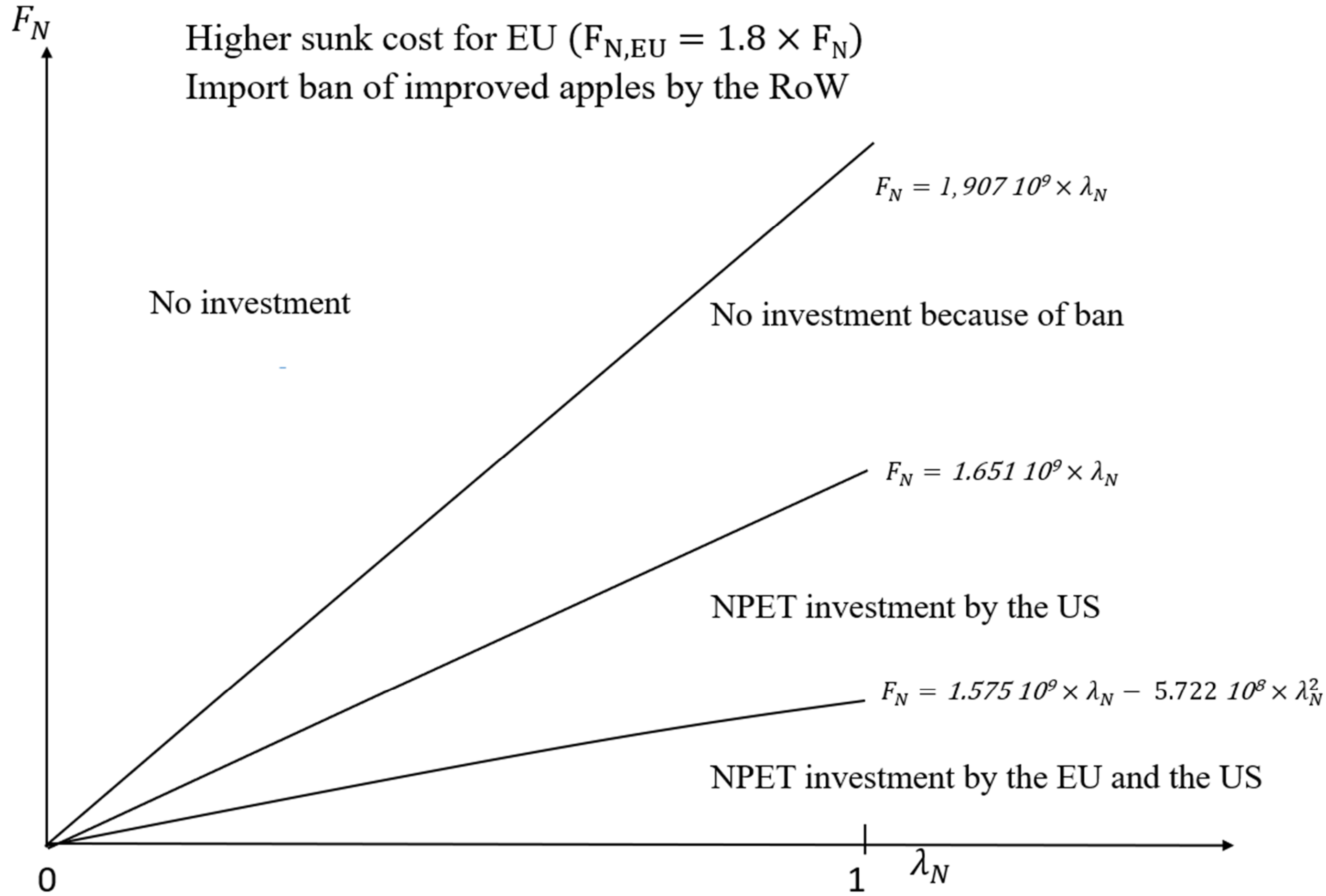
Figure 1. R&D investment accessible for both the EU and the US



Beyond the asymmetric cost structure arising with different regulatory costs in R&D, a second scenario looks at potential import bans which could impact the market potential of the innovation. The analysis considers a ban on NPETs-based novel foods in the third market of the rest of the world. Figure 2 builds upon the right-hand-side quadrant of Figure 1 and introduces a ban on NPETs in the rest of the world shown in Figure 2. (RoW in Figure 2).

The import ban modifies the incentive for innovating since potential profits from exporting improved foods to the RoW disappear for both countries. Compared to the right panel of Figure 1, frontiers separating R&D participation zones pivot downward in Figure 2. They imply some decreased ranges in R&D investment undertaken by the US and the EU. This occurs both when they invest together, when the US remains the single investor, and when prospects deteriorate with lower probabilities of success and/or higher sunk cost. Hence, the ban in third countries reduces the expected profitability of innovating using NPETs and both competitors revert to more conventional hybridization methods to innovate, which are less efficient.

Figure 2. Investment accessible for both the EU & the US, import ban in RoW



In summary, the analysis indicates that R&D investment for foods improved with NPETs may be compromised by import bans for high values of sunk cost. This would occur despite the fact that a global social planner maximizing expected global welfare opportunities would have allowed NPETs in all markets. Scale in production post-innovation allows to spread the sunk cost of R&D across more units. Scale is partly achieved in the domestic market (the case of the EU apple market) but is also attained with international trade. This is especially the case for smaller countries, which may have the scientific capability but a small domestic market. When streamlined and science-based regulations allow for R&D innovation, production, and consumption of NPETs-based novelties, global welfare can be maximized while consumers still have the choice between traditional food and novelties. Regulatory harmonization or reciprocity across borders are important policy dimensions to consider to reduce the cost of innovation.

For further readings

Beghin, J. “Willingness to pay for genome edited food.” *Cornhusker Economics*. September 2021.

Marette, S., A-C Disdier, A. Bodnar, and J. Beghin. “New Plant Engineering Techniques, R&D Investment, and International Trade.” *Journal of Agricultural Economics* 74, no. 2 (2023): 349-368.

Marette, S., J. Beghin, A-C Disdier, and E. Mojduszka. "Can foods produced with new plant engineering techniques succeed in the marketplace? A case study of apples." *Applied Economic Perspectives and Policy* 45(1) (2023): 414-435.

Marette, S., AC, Disdier, and J. Beghin. “A Comparison of EU and US consumers' willingness to pay for gene-edited food: Evidence from apples.” *Appetite* 159, (2021): 105064.

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