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Productivity Gains for Joint Products

Andrew Schmitz[1]*, P. Lynn Kennedy[2]

[1]*University of Florida, Gainesville, USA*

[2]*Louisiana State University Agricultural Center, Baton Rouge, USA*

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***Corresponding author:** Andrew Schmitz, Food and Resource Economics Department, PO Box 110240, University of Florida, Gainesville, Florida, USA

Introduction

There have been many studies on productivity gains from the development and adoption of new crop varieties [1]. A topic overlooked is the return from investing in research and development (R&D) of joint products. In this paper, we highlight joint product research using as an example Louisiana rice farmers who produce rice and crawfish as a joint enterprise. We explore the implications if one ignores the effects of rice R&D on crawfish production. The majority of the U.S. crawfish industry is located in Louisiana, where over 50% of the state's crawfish aquaculture is practiced in conjunction with rice production [2]. With a life cycle well adapted to rotational farm production strategies, crawfish can be produced either in permanent rotation with a rice crop year after year in the same location or in a field rotation with a rice crop where crawfish are restocked each rotational cycle [2]. Researchers continue to develop technologies for improving crawfish aquaculture, such as the rice-crawfish crop rotation system [3]. The percentage of acreage used for the rice-crawfish crop rotation system has more than quadrupled since the late 1970s, providing producers with a more diversified source of revenue. Many rice varieties have been developed and used in Louisiana rice production, including Magnolia (1945), Saturn (1965), Lemont (1983), Cypress (1993), Cocodrie (2000), and Clearfield Technology and CL Hybrids (2001).

Theoretical Considerations

Section 1

In the following, we provide a theoretical framework for considering the case of joint products. We compare this outcome with the no joint product case.

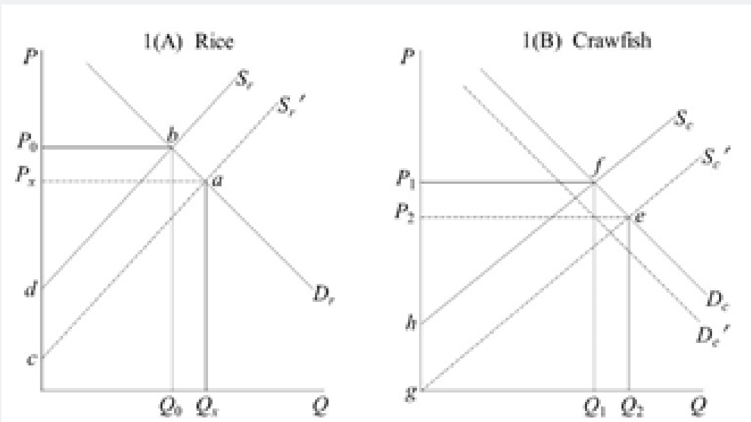

Figure 1: Rice and crawfish.
Source: Authors' data

Consider Figures 1(A) and 1(B). In Figure 1(A), the supply of rice is S_r and demand is D_r. The quantity of rice produced is Q_0 at a price P_0. In Figure 1(B), the supply of crawfish is S_c and demand is D_c. For output Q_1, the market clearing price is P_1.

In this model, rice and crawfish are joint products when the production of crawfish depends on rice production. Consider the introduction of a new rice cultivar that causes the supply of rice to shift from S_r to S'_r. The added rice production causes the supply of crawfish to shift from S_c to S'_c. Due to new technology in rice production, the price of rice falls to P_x and rice output increases to Q_x. For crawfish, the price falls to P_2 and output increases to Q_2. The above models can be expanded to take into account factors in addition to R&D that affect rice and crawfish productivity [4]. For example, (1) the improved use of mechanization would cause the supply of rice in Figure 1(A) to shift rightward from S_r to S'_r, and (2) a drop in crawfish prices due to falling demand causes the demand in Figure 1(B) to shift leftward from D_c to D'_c.

Section II

Table 1 illustrates the effects of introducing a new rice variety resulting from R&D. In the case where rice and crawfish are not joint products, the net gain from rice R&D is $(P_0P_xab)+\{(P_xc)-(P_0db)\}$. In the case of joint products, the net gain from rice R&D is $(P_1P_2ef)+\{(P_2ge)-(P_1hf)\}$ Under the case where rice and crawfish are joint products, consumers benefit along with rice producers who also produce the crawfish from the rice R&D.

Table 1: Rice and crawfish: effects of rice R&D.

Not Joint Products		Joint Products	
Consumers	Producers	Consumers	Producers
(P_0P_xab)	$\{(P_xca)-(P_0db)\}$	$\{(P_0P_xab)+(P_1P_2ef)\}$	$\{(P_xca)-(P_0db)\}+\{(P_2ge)-(P_1hf)\}$

Source: Authors' data.

Observations on the Rice and Crawfish Industry

Ratoon Cropping

An increase in the percentage of southwest Louisiana area producing a ratoon crop and the improvements of ratoon crop production practices also contributes to yield growth rates. In 2020, over 40% of the southwest Louisiana rice area was ratooned – nearly double the percentage from 2000. Research has demonstrated that certain first-crop stubble management practices can significantly increase ratoon crop yields. A combination of a larger number of hectares producing a ratoon crop and overall higher yields in ratoon area has been a major factor in overall yield increases in the region. Given that the average yield of ratoon rice is approximately one-third that of the main crop, the impact on yields can be significant.

Rice-Crawfish Sequential Systems

The percentage of southwest Louisiana rice hectares that are in a rice-crawfish sequential system has dramatically increased since the 1970s, growing from 4.74% of rice hectares in 1978 to 33.34% in 2017. In the rice-crawfish sequential system, the crawfish culture follows the main rice harvest, and the forage crop used for growing crawfish is the crop residue and re-growth of the rice stubble after grain harvest [5]. Crawfish can effectively reduce the weedy/red rice seed bank in the soil, which decreases the number of seeds available to germinate in the rice crop. Despite the benefits of a rice-crawfish sequential system, it is important to note that farmers must typically choose between harvesting the ratoon crop versus the crawfish in a rice-crawfish sequential system. The ratoon crop directly increases the rice yield, whereas the crawfish produced in a rice-crawfish sequential system indirectly increases the rice yield.

The data on rice-crawfish production suggests that rice and crawfish are joint products. Significant growth in yield for both products occurred between 1988 and 2018 (Figures 2 and 3). Data from this period were also examined to determine the relationship between rice and crawfish yields. The results of regression show a positive and significant relationship between rice and crawfish yields, where a one pound per acre increase in rice yield results in a 0.06458 pound per acre increase in crawfish yield (Table 2). Given 2018 yields, a 1% increase in rice yields results in a 0.72% increase in crawfish yields. Based on the example from Figure 1, this would equate to the shift in rice production from to contributing to the shift in crawfish production from to. Thus, any R&D that increases rice yields will have positive spillover effects on crawfish yields.

Table 2: Louisiana crawfish yield regression, impact of rice yield (lbs/acre) on crawfish yield (lbs/acre).

Variable	Estimate Coefficient	t-statistic	P-value	Significance
Constant	154.27	1.48	0.15	—
Rice Yield	0.06458	3.52	0.001	*

*Indicates significance at the 0.001 level

Source: Authors' calculations based on data from USDA-NASS and LSU AgCenter [6,7].

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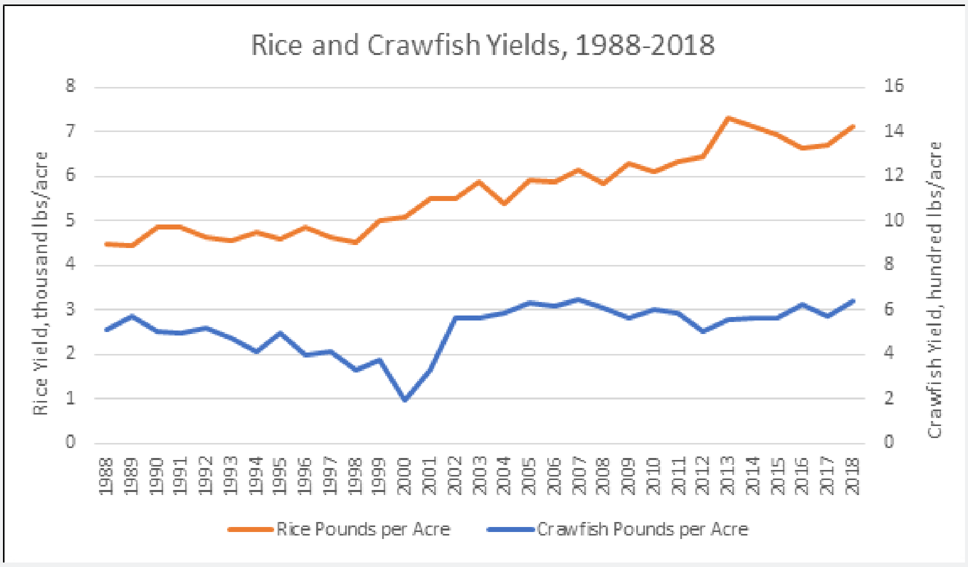

Figure 2: Louisiana rice and farmed crawfish yields, 1988–2018
Source: Author calculations based on data from USDA-NASS and LSU AgCenter [6,7].

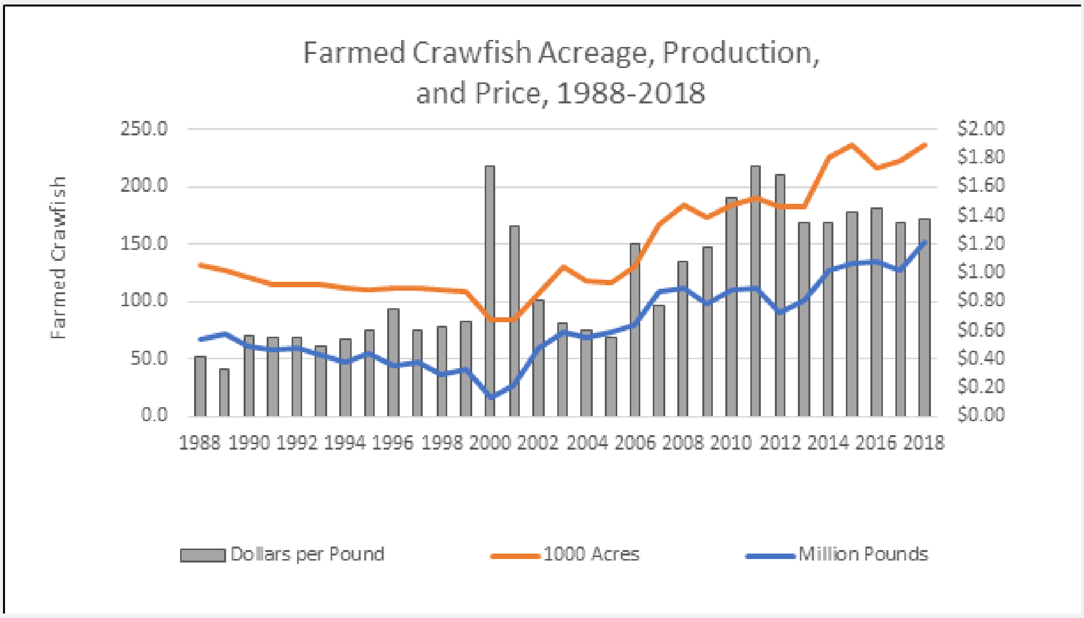

Figure 3: Louisiana farmed crawfish acreage, production, and price, 1988–2018.
Source: Author calculations based on data from LSU AgCenter [7].

Conclusions

We have highlighted a discussion and framework for conducting research on the effects of various factors, including R&D and new varietal development for joint products. This will be helpful for researchers when considering agricultural joint products and how they are affected by new technologies and the like. When joint products exist but are not taken into account in agricultural productivity research, the rate of return from R&D will be understated.

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