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Abstract

Roundup Ready® Wheat (RRW) was one of the first genetically modified (GM) traits for the wheat sector and was under review by regulatory agencies in the United States and Canada when Monsanto withdrew it from further consideration. There are a multitude of issues associated with the *ex ante* evaluation of this decision. These include market acceptance and segregation, as well as the varying sources of cost savings and productivity gains. In this article, we develop a spatial partial equilibrium model of the higher-protein hard wheat market and assess the changes in the distribution of welfare associated with release and adoption of RRW. It incorporates segments for GM aversion in each market and segregation costs for each segment. Major conclusions indicate that in the most likely scenario, producer welfare increases by $301 million and consumer welfare increases by $252 million. Producers of hard red spring (HRS) wheat in the United States and Canada win, while hard red winter (HRW) wheat growers lose.

Key Words: genetically modified grains, welfare analysis, wheat

Overview

An important challenge confronting the hard wheat market in North America is the release and adoption of RRW. This is the first trait for the wheat sector and is currently being reviewed by regulatory agencies in the United States and Canada. There are a multitude of issues associated with the *ex ante* evaluation of this decision. These include market acceptance and segregation, as well as the varying sources of cost savings and productivity gains. All these are compounded by U.S.-Canada competition in domestic and international markets and their approach to adoption.

In this study, we develop a comprehensive welfare model of the higher-protein hard wheat market and assess the changes in the distribution of welfare associated with release and adaption of RRW. It is a spatial partial equilibrium model and incorporates segments for GM aversion in each market and segregation costs for each segment. The domestic market and each importing country consist of segments with respect to GM aversion. Suppliers are allowed to adopt or not adopt depending on location and financial incentives to do so, and handlers are allowed to segregate GM from non-GM at different tolerance levels at

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different costs. Other sources of productivity gains and cost savings, some of which vary geographically, are included. The equilibrium is compounded by the spatial distribution of production and demands and domestic and international competition. The model determines equilibrium trade flows, adoption rates, prices and price differentials.

The report makes three general contributions. One is that it comprehensively addresses a very important problem in the world wheat market and extends previous literature in this area. Second, it expands on other welfare studies of GM traits by accounting for market segments and segregation costs which vary by tolerance. The methodological contribution is important. In order to determine equilibrium prices, most other studies make assumptions on adoption and trade flows and disallow segments and segregation. Our model differs in that it determines equilibrium values for adoption rates, prices, and differentials, as well as trade flows. Finally, it builds on previous studies that have analyzed welfare distribution due to RRW. The previous studies were non-spatial models which made *a priori* assumptions with respect to the ability to segregate GM from non-GM and otherwise understated productivity gains and cost savings.

Major Findings

Some of the important facts that have an impact on the results include:

» Supply Function Shifts: In each of the major hard wheat producing states and provinces in North America, there have been significant shifts in the supply functions during the 1990s. These are likely due to the combined impacts of the changes in U.S. farm legislation and the concurrent introduction of competing crops, which in most cases have been GM.

» Productivity Gains: RRW has a yield advantage ranging from 5 to 15% compared
» to conventional varieties and competing treatments. This is comparable to the initial gains associated with biotech corn and is the first major technology breakthrough for HRS since the introduction of semi-dwarf wheats in the early 1970's.

» Cost Savings: Costs savings associated with adoption range related to labor and management savings and other non-pecuniary costs range from $8.30 to $11.57/acre across regions. These are in addition to gains related to yield and reduction in dockage removal costs. In addition to these, non-adopter cost savings related to competing chemical costs are in the area of $2.28/ac.

» Market Acceptance: Each market consists of segments with respect to GM aversion. We considered four potential segments in each country. Taken together, these imply that about 10% of the North American domestic market would require some form of segregation, and about 43% of the offshore market would require segregation.

The welfare model was solved and used to identify changes in welfare, the distribution of welfare changes, prices and differentials, and equilibrium adoption rates associated with the introduction of RRW. Major conclusions indicate:

» In the most likely scenario which we define as Segmented Market Acceptance, producer welfare increases by $301 million and consumer welfare increases by $252 million. These are comparable to the expost estimates of GM traits on other grains.

» Producers of HRS and CWRS wheat gain, and HRW wheat growers lose welfare. The reason for this is due to the technology being available to spring wheat growers and not HRW wheat growers. Further, as noted below, there is an overall price decline which is less than the cost savings to HRS wheat growers, that adversely impacts HRW wheat.

» Consumers in countries and segments allowing GM gain in welfare and those with restrictions, notably the EU and Japan, have reduced welfare. Reasons for this are that their purchases are of a higher cost wheat that has not incurred the technology savings, due to their segregation requirements, and due to minor changes in originations. All other countries enjoy increases in consumer welfare.

» If there were full market acceptance (i.e., as if there were no market segments in any of the countries), total welfare increases to $787 million and, in this case, there is a greater increase in consumer welfare.

» Any form of restricted introduction results in a substantial lesser gain in welfare. Release in the United States only (or only in Canada) results in a much lesser increase in producer welfare and negligible increase in consumer welfare. Release in the United States only results in the United States serving the domestic market which is largely non-averse and many of the smaller international markets. Canada would serve the non-GM market segments, albeit at a higher cost, in order to increase supplies and conduct segregation.

If Japan were to shift all its purchases from the Untied States to Canada, there would be a substantial reduction in welfare gains. In this case, Japan is served by Canada at a higher cost, in part to increase supplies and in part due to segregation costs. The United States serves the domestic market and most of the rest of the world market, in some cases at a higher cost. The combined impacts of these are for a large reduction in both producer and consumer welfare.

In the Segmented Market Acceptance scenario:

» Adoption is greatest in Montana and North Dakota, and North American supplies increase by about 4%.

» Export market shares are largely unchanged.

» Price levels decline in all likely scenarios associated with introduction of this technology. Results indicate prices decline in the area of $7mt. This is as expected and is due in part to the average cost reduction of RRW of adopters in the area of $14/mt. The change in prices varies across scenarios and by wheat class as expected.

» Price differentials emerge in each market and market segment approximately equal to the differentials in costs of production and marketing. These are differentials likely to confront competitors within each country.

Numerous sensitivities were conducted including those related to technology fees, yield changes, and demand assumptions.

Implications

There are many implications of these results including those for public and private policies and inter-country implications.

The welfare gains of RRW are comparable to the estimated expost welfare gains on like traits introduced in soybeans and cotton in magnitude. Due to the increased productivity and market segments, prices decline. The distribution of welfare gains are neither universal nor symmetric. Producers in regions with greater adoption have a greater gain in welfare than others. Producers of HRS and CWRS wheat benefit, but HRW wheat producers lose. The reason for this is that the latter do not benefit from the technology but suffer from the price decline. There are also differential impacts across consuming countries. Those with large segments which are GM tolerant benefit the most. However, those that restrict GM imports, notably the EU and Japan, suffer due in part to the higher costs of production and segregation and to a minor extent the geographic shift in procurement.

Besides the differential impacts among producers and consumers, there are two areas that may be influenced by public policy. One is to improve, however possible, acceptance of GM wheat. In these results, the non-GM market segments comprised about 10% of the domestic market and 44% of the export market. Welfare improvement of full versus segmented market acceptance is about $234 million. This is sizable and results in improvements for all sectors. If other traits are commercialized, its impact would become even more important. While we recognize efforts are underway to improve and facilitate acceptance, there is certainly room for greater concentration of initiatives toward this end.

The second relates to segregation costs. We allow for reasonable costs of segregation in determining our equilibrium results. However, a number of requisites are necessary to achieve these, including the availability of low-cost repeatable tests, certification, and mechanisms to facilitate variety declaration. Each of these can be influenced by the public sector. Looking beyond the equilibriums presented here, an important area of intercountry competition will be the countries' ability to perform these functions at lower costs than their rivals. Again, the ability to do so can be influenced by policies and initiatives.

Three sets of private sector implications are discussed. Growers will be confronted with another production choice that has implications for farm management. These will also affect marketing decisions and will be impacted by price differentials, contracting mechanisms and obligations, and the prospective need to maintain segregations and assure improved variety purity. Handling firms and exporters will compete in this bifurcated market based on segregation costs and risks. Further, non-GM buyers with tight tolerances will likely require closer buyer-seller relationships and be less transactional versus conventional marketing. Finally, inter-segment competition amongst processors will be intensified with the introduction of GM wheat. Notably, processors of products requiring non-GM or limited amounts of GM for marketing purposes, will confront greater competition from those that do not, due in part to the lower cost ingredients available to the latter.

Finally, there are strategic implications for intercountry competition between the United States and Canada. Regions within these two countries already have different institutional mechanisms that facilitate quality and marketing and compete vigorously in most markets. If both countries adopt, both gain comparably, with Canada gaining slightly more due to its large acreage. Export market shares are largely unchanged. If one adopts and the other does not, the results change drastically. If there were asymmetric adoption, the more likely case would be the United States adopting first.

One way to view this strategic rivalry would be that of tough commitments when prices are strategic complements (Below, Geanakopolos, and Klemperer 1985) in 2-stage games. In stage 1, the United States adopts a cost reducing technology. In the second stage, Canada and the United States compete, most likely on prices. A strategic commitment such as a technology that is cost reducing is thought of as "tough" (i.e., any commitment that would be bad for competitors, but it must be transparent and irreversible). Any such commitment would have direct and strategic price effects. The characteristics of the commitment (tough or soft) and 2nd stage competition impacts the longer-run equilibrium.

The asymmetric release and adoption by the United States would be interpreted as a tough[1] commitment to both reduce costs and segregate non-GM. Conceptually, this would be equivalent to a leftward shift in the U.S. reaction function in Bertrand competition, assuming prices are strategic complements. The impact of this would be reducing prices in each country, but a larger price reduction on its own price. The strategic side effect of the commitment is for a price reduction in both countries. In this case, the negative strategic effect is less than the direct effect. Fudenberg and Tirole (1991) refer to this

[1] A soft commitment, in contrast, would be one that would result in less production than otherwise would have been the case–which is not the case here and would lead to higher prices.

as a “Mad Dog” strategy–i.e., with strategic complements, making a tough commitment is akin to an “attack to become top dog, invite battle heedless of costs.” Both the direct and strategic effects should be considered in assessing how such decisions will affect future competition.

Results from our models can be used to interpret these strategic effects. If the United States adopts and Canada does not, the former makes a tough 1st stage commitment. This has the impact of reducing costs by about $14/mt on average for adopters. Equilibrium prices in the 2nd stage drop by about $7/mt. Thus as the mad dog, the United States would accrue a cost advantage greater than the reduced equilibrium price change (i.e., the strategic effect would be negative, but not as great as the direct effect). Canadian and HRW wheat growers would be adversely impacted by having to compete against a lower cost competitor. This differential advantage would give the United States a first mover advantage and would be retained until Canada adopts similarly at which time it would diminish.

Of course, there are many other impacts of such an asymmetric release which are not considered here. One is the assurance that proposed segregation mechanisms will serve the needs of buyers. The second is that in such a bifurcated market, Canada gains in the large stable Japanese market (assuming Japan would allow itself to be subjected to a bilateral monopoly structure for purchases), and the United States gains in other markets, which are typically smaller and more volatile.

Limitations

All of the assumptions and relationships used in this study are based on recent, and in most cases, refereed published sources and should be accepted as plausible. Hence, most of the limitations relate to factors not allowed in the welfare model. There are several which are acknowledged.

The model does not consider impacts on other small grains and organics. As production of GM HRS and CWRS wheat improves in profitability due to this technology, other sectors not benefitting from the technology will be adversely impacted. These include other small grains, notably durum wheat, malting barley, etc., and the organic production of HRS wheat. These sectors will suffer in part because their opportunity cost will increase, much like has occurred between these and other current GM row crops, as well as between HRS and HRW wheat as illustrated in this analysis. They will also suffer to a minor degree to the extent that they may require more onerous segregation and/or certification processes to assure their purity when grown or handled in non-specialized farms and facilities.

A second consideration is that it disallows emergence elsewhere in the world for non-GM higher-protein hard wheat as a substitute. We view this as somewhat unlikely. While minor amounts of higher-protein APH are exported from Australia, the overall protein level has been declining in that country for many years despite attempts to reverse its decline. Other countries do not export notable volumes of higher-protein wheats with the functional characteristics of HRS wheat. If these countries could competitively produce these wheats, one would have thought they would have already done so given their value. The Former Soviet Union (FSU) and other eastern European countries are somewhat of a wild card on their ability to export wheats competitive with those in North America. Nevertheless, the approach here is not limiting because GM averse buyers are allowed to substitute the higher cost of segregation from the United States and Canada for the lower cost GM wheats. Finally, from a practical matter, we have to acknowledge that some of these competing regions are developing GM wheats, though their release is not imminent.

Third, we assume the market equilibrium is determined competitively. Strategic behavior of suppliers is ignored both on the part of importers and exporters. While we recognize there may be alternative assumptions on this topic, it seems reasonable. Essentially, we allow a large number of competing regions to compete among one another through a competitive export industry to supply to a large number of independent and spatially separate demanders that are assumed to be atomistic. Other approaches could be considered, but to do so would be by assumption, and we do not have access to data that would allow verification of alternatives. Hence, the competitive assumption used here is retained and defendable.

Finally, we consider only one GM trait, that being RRW which has already been deemed as substantially equivalent to conventional varieties. There are other GM traits under development but their release is years away and measures of their potential productivity gains and/or cost savings do not exist.

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