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Farm equipment industry performance: past and future

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Abstract

This paper assesses the agricultural equipment industry through the perspective of the three leading firms in the United States. It reviews the salient events of the 1990s and relates the business environment to the firms' financial performance. It then assesses the factors likely to impact performance in the future, drawing on lessons from historical performance and on new environmental factors. The firms' capital market valuations appear consistent with the expectation that farm equipment firms will resume growth after the farm recession.

Key Word: Farm equipment industry

1. Introduction

Agricultural equipment has been a major contributor to the agri-food sector throughout U.S. history. It has played a major part in the modernization of agriculture, consistently improving farm productivity and commanding an increasing share of the economic value added to farm produce. While agricultural equipment contributes a significant share of the value created in the agri-food sector, an important question is how much value the agricultural equipment industry will contribute to the farm and food sector in the future. The purpose of this paper is to examine trends and fundamental uncertainties in the business

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environment, their potential outcomes, and their related impacts on the equipment companies' expected performance and value.

We review the prospects for the industry through the three leading farm equipment manufacturers in the United States: Deere and Company (Deere), J.I. Case Corporation (Case), and AGCO Corporation. These constitute three of the world's four leading firms along with the New Holland Corporation based in the United Kingdom. New Holland made a bid in May 1999 to acquire Case, and completed a merger in November 1999 (becoming CNH Global, N.V.). In 1998, Deere and Company was the largest equipment company with total equipment sales revenue of approximately $11.9 billion (Deere and Company, 1998, p. 28). In comparison, Case and AGCO respectively generated total equipment sales revenue of $5.7 billion and $2.9 billion in 1998 (J.I. Case Corporation, 1998, p. 42; AGCO Corporation, 1998, p. 28). AGCO has a distinct low-cost strategy, outsourcing more of its parts and equipment production, with multiple brands (AGCO Corporation, 1996, p. 1).

A key issue for future performance is how much of farm production value can be contributed by the farm equipment industry and how much of this can the firms capture as profits. This cannot be measured or reliably estimated, but we may be able to make some general inferences based on expected firm performance. Equipment sales represent the value of farm production appropriated by farm equipment industry. If these growth rates are similar, and if return on investment to the farm equipment industry is constant then this would imply no growth in the value contributed by the farm equipment industry. In this study, we identify important factors and uncertainties that will affect future outcomes, and provide an assessment of the prospects. We begin with a review of the general business strategies and performance of the firms through the 1990s. We relate the competitive issues to the historical financial performance of the firms. Lastly, we examine opportunities and threats that have the potential for a long-term impact on the industry business environment and relate these to potential future performance.

2. Historical firm events and performance

To gain an understanding of the industry we evaluate the history and performance of the three leading U.S. farm equipment firms. General historical financial data for the three firms back to 1994 are shown in Table 1. Table 2 gives more detailed information on the performance of the three farm equipment businesses in the 1990s, and on the finance subsidiaries for Case and Deere.

2.1. AGCO Corporation

While AGCO was formed in 1990, its formation can be traced to the mid-1980s farm recession when, in 1985, the Allis Chalmers Corporation sold its agricultural division to a German-based company, Klochner-Humboldt-Deutz (KHD). In 1988, KHD hired Robert J. Ratliff as the president and CEO of Deutz-Allis because the company was struggling financially. With the fall of the Berlin Wall (1989) and totalitarian regimes, management perceived growth opportunities in Eastern Europe along with existing markets in Western

Table 1
Historical financial data of farm equipment companies ($ millions)

	1998	1997	1996	1995	1994
AGCO					
Sales	2,941	3,224	2,317	2,068	1,319
Net Profit	57	241	167	175	81
Assets	2,020	1,807	1,405	1,062	896
Liabilities	1,008	799	626	473	420
Net worth	1,012	1,009	780	589	477
Case					
Sales	5,738	5,796	5,176	4,937	4,262
Net Profit	88	234	297	188	29
Assets	4,555	3,630	3,345	3,200	3,474
Liabilities	2,331	1,337	1,379	1,627	2,245
Net worth	2,224	2,293	1,966	1,573	1,229
Deere					
Sales	11,926	11,082	9,640	8,830	7,663
Net Profit	1,120	960	756	793	644
Assets	9,599	8,251	7,702	7,479	6,982
Liabilities	4,403	3,034	3,078	3,419	3,421
Net worth	5,196	5,217	4,624	4,060	3,561

Europe and Northern Africa (Barry, 1997; Nesbitt, 1990). In 1990, Ratliff led a management buy-out whereby KHD sold Deutz-Allis to Ratliff and four other Deutz-Allis executives (Barry, 1997). From the buy-out, Ratliff and his management team formed the AGCO Corporation (acronym for Allis-Gleaner Corporation) and moved the company's headquarters to Duluth, Georgia (PR Newswire, 1990). AGCO has become one of the largest agricultural equipment companies in the world with significant shares in many world markets.

AGCO has developed a unique multi-brand line of equipment through numerous acquisitions of financially struggling equipment companies (Barry, 1997). Principal acquisitions have been: Hesston (hay and forage equipment) and White (high horsepower tractors) in 1991 (AGCO Corporation, 1992, p. 17); Massey Ferguson North America and White-New Idea in 1993; Massey Ferguson Limited in 1994; Spra-Coupe, and Willmar, as well as the distribution rights to Massey Ferguson equipment in Argentina in 1998 (AGCO Corporation, 1998, p. 4, 1998a, b). Prior to its acquisition of Massey Limited, AGCO's revenues came primarily from North America (Barry, 1997). The Massey Limited acquisition doubled AGCO's sales and resulted in 57% of AGCO's total sales coming from outside North America (AGCO Corporation, 1994, p. 4). AGCO does not change acquired brand names because it believes that many farm equipment customers are brand-loyal. As a result, by 1998 AGCO offered 17 different brands of equipment and had significant market share in the agricultural equipment industry (AGCO Corporation, 1998, p. 3; PR Newswire, 1993).

Complementing AGCO's multi-brand strategy, the company has developed a unique distribution network through its acquisitions. AGCO has designed its equipment distribution network such that it encourages "crossover contracts" which allow equipment dealers to sell many of the multiple brands of equipment that AGCO has acquired (AGCO Corporation,

Table 2
Historical performance of farm equipment companies in 1990s

	1998	1997	1996	1995	1994	1993	1992	1991	1990
Sales Growth									
AGCO	−8.8%	39.1%	12.0%	56.8%	121.5%	89.4%	14.6%		
Case*	−1.0%	12.0%	4.8%	15.8%	13.7%				
Deere*	7.6%	15.0%	9.2%	15.2%	18.3%	13.2%	−2.1%	−13.7%	8.7%
Invested Capital Turnover (Sales/Beginning Invested Capital)									
AGCO	1.71	2.26	2.09	2.61	2.31	1.90	3.20		
Case*	2.12	2.33	2.16	2.08	2.60				
Deere*	2.14	2.06	1.77	1.63	1.40	1.29	1.12	1.14	1.54
Return on Sales (Net Operating Profit/Sales)									
AGCO	3.0%	8.3%	7.4%	8.9%	6.7%	5.1%	3.4%		
Case*	0.9%	3.3%	4.5%	2.9%	−0.6%				
Deere*	7.5%	6.8%	5.3%	6.8%	6.1%	1.7%	−0.9%	0.0%	6.2%
Return on Investment (Invested Capital Turnover × Return on Sales)									
AGCO	5.1%	18.7%	15.4%	23.2%	15.4%	9.6%	10.9%		
Case*	1.9%	7.6%	9.7%	6.1%	−1.6%				
Deere*	16.0%	14.0%	9.4%	11.1%	8.6%	2.2%	−1.0%	0.1%	9.6%
Return on Financing Investments									
Case	11.5%	11.8%	15.0%	13.0%	8.5%				
Deere	10.7%	11.0%	10.5%	14.5%	16.9%	15.3%	15.5%	14.5%	13.8%

* Results for Case and Deere for equipment subsidiaries only.
Finance subsidiary results shown in bottom section.
Note: AGCO became a publicly traded company in 1992.
Note: Case was spun off from Tenneco and became an independent traded company in 1994.

1997, pp. 3–5). As a result, the equipment dealers can then better target the numerous different brand-loyal customers.

Finally, a key element to AGCO's strategy is low-cost manufacturing with the outsourcing of a significant portion of parts and equipment production (PR Newswire, October 23, 1997). It has developed manufacturing systems based on a high proportion of relatively standardized parts, many from outside suppliers, saving internal research and development costs. AGCO often outsources production of its equipment by entering into joint ventures with other manufacturing companies. These joint ventures are typically with other manufacturing companies that AGCO has only partially acquired, or with companies to which AGCO has sold acquired production operations. For example, in 1996 AGCO acquired all of Deutz Argentina S.A., but in January 1998 AGCO sold 50% of the Deutz Argentina engine business to Deutz A.G. who had agreed to produce engines for AGCO (PR Newswire, January 5, 1998). By outsourcing much of its equipment production, AGCO can respond more efficiently to changes in the demand for agricultural equipment, less burdened by large fixed asset investments (PR Newswire, October 23, 1997).

In 1998, the company experienced its first sales decline (−8.8%) due to the economic crisis in Asia and weakened global demand for agricultural equipment (AGCO Corporation, 1998, p. 2). AGCO maintained positive profits in 1998 which it credits to its outsourcing and distribution strategies (AGCO Corporation, 1998, pp. 2–3). However, while outsourcing

reduces capital usage and increases capital efficiency, AGCO's asset efficiency has declined and been surpassed by both Deere and Case. This is measured in terms of the asset turnover ratio, an accounting measure of how much sales the firm generates from each dollar of beginning investment (Sales/Beginning Invested capital; see Table 2). This decrease is due partly to AGCO's significant acquisitions of firms having more internalized operations and to medium-term inefficiencies of integrating new operations. Acquisitions have also burdened AGCO's turnover ratio by adding intangible asset investments in the form of the acquisition purchase amounts in excess of the identifiable assets of the acquired firms (i.e., "goodwill"). This represents invested capital on which the AGCO must earn a competitive return. AGCO has also invested in precision agriculture through its Fieldstar® system. Despite the decrease in asset turnover, AGCO's return on sales has held up well, and AGCO's overall return on investment has usually exceeded that of Deere and Case through the 1990s.

2.2. J.I. Case Corporation

The J.I. Case Corporation was founded in 1842 by Jerome Increase Case, and soon gained recognition as the first builder of a steam engine for agricultural use. By 1970, Tenneco, Inc., of Houston, Texas, acquired Case and made the company one of Tenneco's wholly owned subsidiaries. In 1985, during the farm recession, Case acquired International Harvester and so became the world's second-largest agricultural equipment manufacturer. In 1986, Tenneco acquired Steiger Tractor, Inc. for Case, making it one of only two North American equipment manufacturers to produce four-wheel-drive tractors with more than 200 horsepower (J.I. Case Corporation, 1998a).

Coming out of the farm recession, farm income was reaching record levels by 1990. Yet, most equipment companies were pessimistic about the duration of favorable conditions and began to cut back on production. Case continued producing at high levels, however, which hurt their performance as economic conditions did worsen (Egerton, 1991; J.I. Case Corporation, 1998a). By 1991, Tenneco decided to try and sell Case for *one dollar* to anyone who would be willing to take it along with its $1 billion debt (Yates, 1995). There were no buyers.

Case next initiated a multi-year restructuring program at a total cost of $1.4 billion. It reduced excess inventory, closed five of its twenty manufacturing plants, and reduced employees from 30,000 to 17,000 by 1994 (Yates, 1995). Case then sold the majority of its company-owned retail stores to independent dealers whom it believed could market and distribute the company's products more efficiently (J.I. Case Corporation, 1994, p. 25). After the second phase of Case's restructuring program was implemented in 1993, economic conditions began to improve and Tenneco spun off a majority of its interest in Case into an independent, publicly traded company (Yates, 1995; J.I. Case Corporation, 1994, p. 21).

Case currently does business in over 150 countries. Case also manufactures construction equipment, and offers financial credit services (J.I. Case Corporation, 1998, p. 27). Case seeks to produce technologically advanced agricultural equipment. In 1995, Case introduced its precision agriculture technology, known as Advanced Farming System™ (Savage, September 27, 1995). In 1996, Case acquired Concord, Inc., providing Case with the best selling air drills in the United States and with technology needed to integrate its Advance Farming

System™ into its planting equipment (Savage, November 1995; Milwaukee Journal Sentinel, 1996; Business Wire, 1996). Also in 1996, Case increased its market share by acquiring both (i) Austoft Holdings Limited, giving Case a new market entry into Taiwan, Thailand, and Brazil, and (ii) Steyr Landmaschinentechcik AG, building Case's business in Germany, France, Austria, Switzerland, and Italy (Savage, 1996; October 1997; Chicago Tribune, 1996).

While Case has experienced some improvement and success from restructuring, it did not yet earn a competitive return from the equipment subsidiary (contrary to its financial services subsidiary). As an independent company, Case's return on sales and overall return on investment lagged behind both AGCO and Deere (Table 2). Performance began to deteriorate in 1997 and 1998 due to the financial crisis in Asia (J.I. Case Corporation, 1998, p. 2). Performance declined further in 1999 in terms of both sales and profitability as the industry continued in recession.

2.3. Deere and Company

Deere and Company was founded in 1837 by pioneer blacksmith, John Deere. Deere is the world's largest manufacturer of agricultural equipment and has been the industry leader for several decades. Headquartered in Moline, Illinois, Deere does business in over 160 countries and employs over 35,500 people worldwide. Deere also manufactures construction machinery, lawn and garden equipment, engines, and other types of equipment. In addition to manufacturing, Deere also offers financial services.

Like Case, Deere seeks to provide its customers with technologically advanced equipment. In 1996, Deere introduced its precision agriculture technology, the "GreenStar™ Combine Yield-Mapping System" (Williams, 1995; Deere and Company, 1995, p. 8). Deere designed its precision agriculture technology so that it would be compatible with Deere combines dating back to 1989, and has been offering the technology on its tractors, planters, drills, and sprayers (Williams, 1995; Runningen, 1995). In 1997, Deere launched the first track tractors in the 160 to 225 horsepower range in which Deere claims to offer some of the most technologically advanced features ever (PR Newswire, June 19, 1997).

Deere is more vertically integrated through greater internalization of parts and equipment manufacturing relative to AGCO or even Case. This gives Deere greater control in its pursuit to build advanced, integrated equipment systems. Deere's acquisitions are far fewer than those of AGCO and Case, and they tend more to be vertical rather than horizontal. For example, in March 1999, Deere acquired InterAg Technologies, Inc., a supplier of software components with capabilities in technologies that Deere uses (Deere and Company, 1999).

Vertical integration requires greater investment than outsourcing strategies, and this is reflected by Deere's historically lower asset turnover ratios in Table 2. However, Deere's turnover has steadily improved and surpassed AGCO in fiscal year 1998. Deere is considerably larger than AGCO or Case, which affords greater scale economies. Deere has invested in new manufacturing technologies and otherwise worked to improve efficiencies over the past decade (Dunn, 1998; PR Newswire, January 29, 1998).

In addition to manufacturing technologically advanced products, Deere has long had a distinct competency in customer service. Deere continues to develop its service and build

longterm relationships with customers. In 1993, Deere began to use its assembly-line work force as marketing representatives on the basis that they could provide better technical support to the company's dealers and customers (Paley, 1994). Deere also developed a customer database to better target marketing messages and better identify after-market support service needs (Yeck, 1997). They have redesigned their distribution network with centralized warehousing to monitor and respond more efficiently to dealer inventory needs (Marchelti, 1998).

Deere has pursued international growth primarily through joint ventures, and marketing and sales agreements rather than acquisitions. This is consistent with Deere's strategy that emphasizes more vertical integration and a single brand, and is distinct from Case and AGCO which have pursued growth more through horizontal acquisitions. Deere has pursued markets in the former Soviet Union, China, Brazil and Argentina, all key international growth markets (Banham, 1996; Gunset, 1997; USA Today, 1999).

Table 2 summarizes Deere's performance through a full industry cycle from the last farm recession in the early 1990s to the current recession that began in 1998. Deere's performance in 1998 did not clearly weaken from the Asian recession and its lingering effects on world crop prices and farm income. This is partly because Deere's equipment division is more diversified and includes construction equipment (as is Case's). However, Deere's cash flow declined in 1998 as proportionately more investment became tied up in working capital. Further, financial results and forecasts for the year indicate a clear downturn for 1999 (e.g., see Deere and Company, 1999).

3. Value and future performance

What will happen to these agricultural equipment manufacturers' performance in the future? While it is unpredictable, we can make some assessments of expected future performance through the firms' capital market valuations. Capital markets allocate wealth in pursuit of financial returns, and market valuations represent collective expectations of the firms' net future cash flows. Because U.S. capital markets are efficient at incorporating information and knowledge into prices, resulting valuations represent relatively informed and unbiased predictions about future performance (efficient markets hypothesis; e.g., see Brealey et al., 1999, pp. 322–335).

3.1. Market value measures

Table 3 shows the market value for each firm as of the last trading day of October 1999 (29 October 1999). The first row of Table 3 shows the size of each firm in terms of the market value of its equity, consistent with the order of 1998 sales levels. We can also see that AGCO is the lowest valued firm by the standard scale-independent valuation metric, the Market/Book equity value ratio (Market value of firm equity capital/Historical cost accounting book value of firm equity capital). This ratio measures the extent to which the market values a dollar's worth of a firm's equity investment at original cost (accounting-book value) (Table 3). This measure is analogous to Tobin's *q* for *total* capital which represents the market value

Table 3
Market valuation of farm equipment companies at October 29, 1999

	AGCO	Case	Deere
1. Market value of equity ($ millions)	$ 640	$4,120	$ 8,470
(price per share value in parentheses)	(10.75/sh)	(53.00/sh)	(36.25/sh)
2. Market value of debt ($ millions)	795	1,956	4,151
3. Total market value of firm (equity plus debt, $ millions)	$1,435	$6,076	$12,621
4. Market/Book equity value ratio	0.56	1.85	1.34
5. Present value of economic profits/Total market value of firm	0.31	0.42	0.47

Note: Price/Earnings (P/E) ratios are not shown because they are not meaningful: AGCO and Deere both had losses (no ratio); Case's earnings were too small and yielded an extremely high P/E of 171.

Definitions:

1. Market value of equity = Number of common shares outstanding × price per share.
2. Market value of debt = total interest-bearing debt (non-interest-bearing liabilities are classified within working capital; Copeland et al., 1996, p. 164, 168).
3. Total market value of firm = (1) Market value of equity + (2) Market value of debt.
4. [Market/Book equity value] ratio = Market value of equity/Accounting book value of equity (Brealey et al., 1999, p. 467).
5. [Present value of economic profits/(3) Total market value of firm] ratio indicates how much of the total market value of the firm must be realized through extra-normal returns beyond the cost of capital, whereby higher ratios indicate stronger expected future performance; for each period, Economic profits = (Return on investment − weighted average cost of capital) × Invested capital (Copeland et al., 1996, pp. 149–151).

of (i) the total intangible capital (including unique, rent-generating knowledge, or growth opportunities), plus (ii) the replacement value of total tangible capital, all divided by the replacement value of the total tangible capital, $q \equiv$ (Market value of total firm capital)/(Replacement value of firm tangible capital). Based on the efficient markets hypothesis, q-theory holds that the effects of information relevant to the firm's expected performance are incorporated into its total market value, the numerator of q (Tobin, 1969; Brealey et al., 1999, pp. 467–468). Tobin's theory is that firms with higher q ratios can create more value from additional capital investment and, so, will attract and invest more capital (strictly, q theory holds for marginal q when different from average q; e.g., see Hayashi, 1982). Analogously, Table 3 indicates that AGCO equity capital is valued by the market at less than its original book investment cost. By contrast, Case and Deere's equity are each valued more than book value implying stronger future investment and return opportunities.

3.2. Relative value in terms of expected performance scenarios

We also use the firms' capital market valuations as a benchmark to assess expected performance through a conventional discounted cash flow valuation model (e.g., Copeland et al., 1996). The present value of the firm's net cash flows from a pro forma model of operating and investment cash flows are calibrated to the actual market value. Model pro forma amounts are developed from benchmarks analyzed from the firms' historical financial statements, including interim statements for the first nine months of 1999. Model valuation is ultimately determined by the discount rate, annual sales growth rates, operating asset levels and related investment cash outflows, and cost and expense outflows and resulting after-tax

operating cash flows from operations. The discount rate is a weighted average cost of capital. The cost of debt capital is estimated from company financial statement disclosures on debt, and the cost of equity capital is the market equity risk premium of five percent plus the risk-free rate estimated from the long-term government bond yield (Copeland et al., 1996). This equity cost represents a modified Capital Asset Pricing Model estimate whereby the market risk premium applies to all firms ("beta" equals one for all firms) because measurement errors can be significant for single firm estimates and thus add noise with little information.

While the ultimate reasons for expected performance and valuations are unobservable, we can assess the relative differences in the expected performance that are implicit in the market values. The pro forma valuation model parameters and values are calibrated so that the model value equals actual market value. Thus, market value is an observable single summary statistic of expected performance and risk, but with sub-components and driving factors being unobservable.

Table 3 shows an expected performance ratio measure for each firm, Present value of economic profits/Total market value of firm. This ratio represents the present value of the net returns in excess of the cost of capital (economic profits or extra-normal returns; Copeland et al., 1996, pp. 149–151), scaled by the total market value of the firm. The cost of capital represents the beginning total capital balance multiplied by the weighted average cost of capital. This ratio is higher if the firm has a higher expected return on investment and higher expected growth, but is *invariant* to what combination of profit rates and growth rates achieves its market value. Thus, this ratio is correlated with the market-to-book ratio but is more accurate since it is based on a full pro forma model that measures required firm performance and accounts for expected dilution, gains and losses on asset transactions, and book intangible assets that do not directly correspond to any direct replacement reinvestment. By this measure, we see that Deere's expected performance is comparable to Case's.

3.3. Firm-specific value factors

While Case is valued highly, like Deere, its valuation is derived not entirely from expectations of internally generated value. New Holland bid to purchase Case for $55 per share which is over double the low price that Case reached in early 1999 (market price stood at $53 per share on the October 29, 1999 valuation date in anticipation of the merger that was completed in November 1999). A rationale for the higher valuation is that the merger would allow distribution synergies from combining Case's North American strength in heavy equipment with New Holland's complementary global franchise and dominance in light equipment. Further synergies are expected from the merged operation reducing total annual operating expenses by up to $500 million within the next three-to-four years (Raghavan and Quintanilla, 1999). These efficiencies can result from scope economies in sharing of operations and distribution assets, or sharing knowledge and capabilities such as research and development. The merger of Case and New Holland represents a consolidation that is characteristic of slow growth industries in a recession. Consolidation may be required more generally to maintain or build return on investment in the industry. After the last farm recession, AGCO was essentially built from consolidation of numerous smaller firms with

associated cost reductions, as discussed earlier. Deere is the long-established "blue chip" firm in the group. Case and Deere both have an advantage over AGCO in the current economic climate in that they both have industrial equipment divisions. Although the Asian crisis also affects industrial equipment, it did not hit this industry as hard as it hit agriculture.

The ultimate reasons for AGCO's low valuation are not explicit. It is a smaller organization based on a newer business model, and has a high debt load with weaker credit rating. Its relatively modest valuation may well incorporate greater risk, balancing (i) the possibilities that it may grow more rapidly from a smaller base and prosper from its unique business model with (ii) alternative possibilities that financial stress over the next few years may threaten its operations or even its viability. In sum, the market valuations imply less overall confidence in the future performance of AGCO.

Valuations of all three firms are below their fall 1997 levels when the Asian financial crisis began. Nevertheless, values are now consistent with the expectation that the industry leaders Deere and Case will grow from the current farm recession and earn reasonable returns in excess of the cost of capital. AGCO's value appears to reflect greater risk of stagnant growth without return improvements. We next look beyond firm-specific factors to identify some fundamental forces in the business environment that appear to have the most potential to change the industry.

3.4. Forces in the business environment

Precision agriculture is the next technological frontier in farm mechanization. Traditionally, farmers manage cropping and inputs uniformly across whole fields. Soil fertility, pest infestation and other production variables are managed by data on field averages. Precision agriculture incorporates variable rate technology that allows farmers to manage fields and inputs more precisely by sub-field plots. This involves integrating output information from prior harvests with information on soil and pest characteristics, all developed through global positioning system satellite technology (Runningen, 1995).

However, economic viability of the costly technology has not yet been empirically demonstrated except in some high-value or high-input crops (Dealer Progress, 1998). Generally, data and research on how to interpret information to support input decisions are lagging. Also lagging is average farmer knowledge of information technology. It is uncertain whether or when the industry's investment in the technology, such as AGCO's Fieldstar® system, Case's Advanced Farming System™, and Deere's GreenStar™ system, will yield significant returns.

Significant acceptance of precision agriculture may require substantially more research to develop closer-to-optimal farm input decisions across much more numerous and narrowly defined conditions over different crops. Further, research may have to more clearly demonstrate economic viability for farmers, and farmer knowledge of the benefits will have to increase. Viability may well be helped by the cost of the technology dropping as often happens with information technology. Another inhibitor for farmer acceptance may be "lock-in" whereby the products and their maintenance and upgrades are specific to the manufacturer and related dealers for parts and service. If the technology becomes more interchangeable or universal, a farmer could then deal in a more competitive supply market

with more manufacturers and service providers. This would reduce farmer lock-in and perhaps accelerate adoption. A further limiting factor in developing countries and much of Europe where farm fields are small, is that precision agriculture is capital-intensive and will be less attractive because it requires more supporting infrastructure and large fields.

An uncertainty related to precision agriculture is increased government regulation of agricultural chemical pollution. Government regulations on chemicals have been getting more stringent in the hope of maintaining soil and water quality, enhancing wetlands, and protecting endangered species (Sunding, 1996, p. 1098). U.S. legislation in 1996 set uniform pesticide tolerances for raw and processed foods that requires a "reasonable certainty of no harm" defined as a one-in-million chance of an individual getting cancer from a lifetime of exposure to the food (Hess, 1996). Regulation is also becoming prominent in other countries. For example, recent legislation in Denmark calls for a reduction in the amount of fertilizer used in the country. The law requires farmers to cut fertilizer use by ten percent, establish wetlands, and better use livestock manure (Agra Europe, 1998, p. N1). As chemical application regulations have become more stringent around the world, they have also become more complex. Precision agriculture technology has particular promise in managing and complying with regulations. Increased regulation could lead to a position whereby farmers can most economically comply with laws through the use of precision agriculture technology that allows them to reduce applications in the most sensitive parts of fields.

In general, precision agriculture technology has the potential for reducing other farm inputs. This effectively substitutes the technology for other inputs, allowing the farm equipment industry to capture a greater share of farm value. Precision agriculture technology also has the potential to complement new biotechnologies. For example, if seeds are developed for specific soil types, precision agriculture would lever the value of such seeds by more fully capturing the benefits through site-specific seeding. However, despite the promise, the medium-term obstacles appear to indicate that any significant expected impact of precision agriculture on equipment firm performance is uncertain and apt to be years off into the future. This mitigates precision agriculture's positive impact on expected performance and current firm value.

World economic growth positively impacts farm income and, so, ultimately impacts farm equipment demand. World commodity prices and farm income were relatively high during the 1990s until the collapse of the eastern Asian economies that began in 1997. These economies had been booming with large population segments moving into the middle class. These segments significantly consume more protein and upgrade their diets, and so have a large marginal impact on farm output demand. As a result of the Asian economic crisis, world agricultural commodity prices and farm income plunged while commodity inventories rose (Tomkins, 1998; Waters, 1998). The Asian crisis is currently the central force within the larger question of world economic growth, farm product consumption growth, and ultimately farm income. Economic downturns in other emerging economies such as in the former Soviet Union and Latin America have contributed further to the problem and its persistence. Low farm income and pessimism about a near upturn have depressed demand in the historically cyclical farm equipment industry.

In addition to world economic growth, another uncertainty in farm income is government farm program payments. Government farm programs have represented about two percent of

farm revenues since the last farm recession based on data from FAPRI (1999). The current U.S. program is the Federal Agricultural Improvement and Reform Act (FAIR Act or "Freedom to Farm" Act), a seven-year farm subsidy program enacted in April 1996. The purpose of the Act is to gradually move agricultural production towards a more free market status, to eliminate planting restrictions, to decouple or sever the link between government payments and the types and acreages of crops that farmers grow, and to provide decreasing government payments over the life of the act by not setting target prices for agricultural producers. The Act expires in 2002, at which time farm legislation will, by default, return to the Agricultural Act of 1949, unless new legislation is passed into law (Paarlberg, 1999, p. 36). Currently, the government is moving towards additional aid during the current farm recession, and there has been increased activism for farm assistance. However, there has long been debate about the level of government support to farmers, further implying that the extent of future farm subsidies is fundamentally uncertain.

If the United States retains agricultural supports in some significant form, and if Europe continues agricultural supports, then this should serve to support and stabilize future farm income and consequent demand for agricultural equipment. Because agricultural equipment manufacturing is otherwise a relatively cyclical industry supported by significant fixed investments, more stable demand can lead to higher capacity utilization and a higher long-term average return on investment.

4. Conclusion

The valuations of the three firms are consistent with the expectation that the industry leaders, Deere and Case (and New Holland by implication from its acquisition of Case) will grow and earn reasonably good returns on investment in the years ahead. Despite current depressed industry conditions, the industry is expected to further reduce costs through new efficiencies and consolidation, and earn returns in excess of the cost of capital during future expansionary conditions. The farm recession may, however, cause another industry shakeout that more threatens the profitability of smaller firms.

Development of new products, such as precision agriculture systems, represents the industry's potential for adding new economic value. Precision agriculture technology has the potential to substitute for other inputs such as fertilizer, herbicides, and other chemicals. It also has the potential to complement new biotechnologies (e.g., site-specific seeds) and Internet technologies to generate farm level research and knowledge. This complementarity may stimulate equipment demand to the extent that biotechnology seed products succeed in the marketplace at creating new economic value. As a result, precision agriculture could allow equipment manufacturers to add more value, further substituting for labor as it has for over a century and also substituting information technology for other inputs as is now happening in many industries. Increased chemical regulation may further increase the value (or share of required expenses) contributed by new equipment technologies.

While the potential for precision agriculture lies on the more distant horizon, economic growth in developing countries may have a nearer-term effect. Economic growth in Asia is picking up which will eventually increase farm demand, while the former Soviet Union and

Latin America currently appear less determinate. As the developing world modernizes its own agriculture, low cost manufacturers such as AGCO may be very competitive. In sum, farm equipment manufacturing is not a "growth industry" in that its long-term growth is not expected to exceed growth in the world economy. However, firm valuations appear consistent with modest future growth being derived from still increasing economic value contributed at the farm level through new technology, and from increased farm demand resulting from worldwide income growth.

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