Size Economies and Stratification in Primary Agriculture: Understanding the Implications

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AGRI-FOOD ECONOMIC SYSTEMS

The Issue

The economic health of the Canadian farm segment is a matter of ongoing importance and concern, especially in an environment of more volatile weather and markets, more uncertain geopolitics and trade, and the return of global hunger.

There is a range of metrics that provide measurements relevant to this issue- farm income, farm household income, wealth of farm households, returns to capital invested in farming, etc. Each of these inform certain questions/concerns, and to varying degrees each are impacted by the acute conditions confronting the sector- drought, pests/disease, volatile markets, macroeconomic conditions, market access interruptions, etc., some of which fragment themselves on a commodity basis. The current dialogue on business risk management and disaster recovery programming is consistent with these acute conditions.

Another aspect is structural, relating to the conditions and fate of small farms versus larger farms. If only the very largest of farms were profitable, or if only certain subsets could feasibly make new technology investments, it would give reason to challenge important assumptions and seemingly comfortable historical views of farming in Canada.

The data show that most of the farms in Canada are small, and that they are declining in number, and that average farm sizes measured in either economic or physical terms, are increasing. These are long established trends.

What dynamic drives this trend? One hypothesis is that over time, some small farms grow to medium size, some medium-sized farms grow to be large farms, and some large farms grow to become very large farms in a step-by-step manner- with attrition in each group as some farmers exit due to retirement, low/unsatisfactory returns and/or better returns in alternative employment.

An alternative hypothesis is that increases in average farm size are driven by a more complex and different dynamic entirely, and that the increase in average size is not due to incremental shifts up from one size category to the next and uniformly distributed exits. Rather, it views small and medium-sized farms as struggling to grow- or even hang on- because of the stratification of productive assets and output with the large and very large farms- which are growing in number and economic significance. Competition among farms tends to be more for productive assets than for customers, and well-established economies of size give large and very large farms a competitive advantage in accessing additional assets as these assets become available from all of the other farm size categories. Under this dynamic, the increasing average farm size is simply the large getting even larger, with all other size segments stagnant or declining.

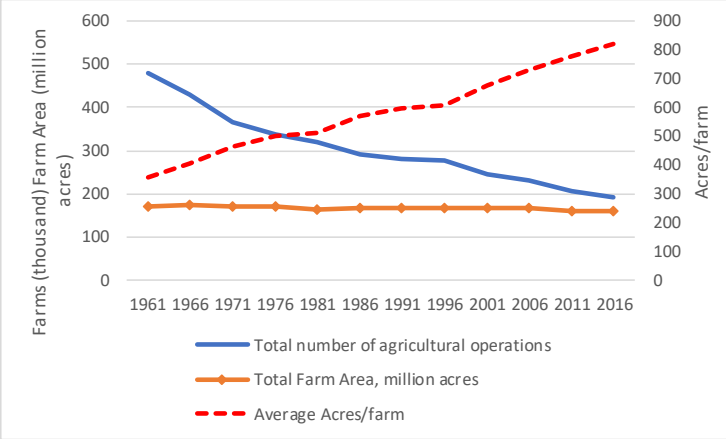
This policy note explores the alternative dynamics of farm structure in Canada, and its apparent implications.

Farm Structure in Canada

The number of farms in Canada is in long-run decline, consistent with trends in place since at least the 1941 census. In turn, it interfaces with a relatively stable arable land base. The clear implication is that average farm sizes are increasing from the perspective of either physical or economic size.

Figure 1 provides the background. Since the 1961 census, the number of farms in Canada has declined from just over 480,000 to less than 200,000. Over the same period, the farm land area declined from about

Figure 1: Selected Demographics of Canadian Agriculture



Source(s): Statistics Canada CANSIM tables 004-0002, 004-0204, and 004-0203

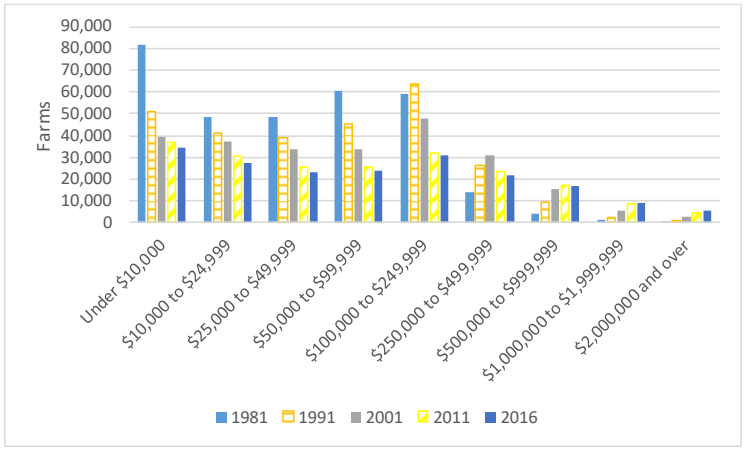
173 million acres to 159 million acres. The implication is that the average acres per farm increased from 359 acres to 820 acres.

One view is that this is a plodding, long term trend driven by marginal changes year by year, leading to larger farm sizes on average. However, digging deeper the data suggests something different.

Figure 2 presents data on farms by economic farm size since the 1981 census, in terms of farm cash receipts (FCR), broken down into economic size categories, and benchmarked to 2015 dollars- to remove the effect of inflation. Within the overall trend of a decreasing number of farms, the following sub-trends can be observed.

- Farms with less than $100,000 in FCR have been decreasing in number since 1981. However, farms with less than $100,000 in FCR represent more than half of farms (56% in 2016); the share of farms with less than

Figure 2: Frequency Number of Farms in Canada by Farm Cash Receipts Class, (2015 $)



Source: Table 004-0006 Census of Agriculture, farms classified by total gross farm receipts at 2015 constant dollars, Canada and provinces

$100,000 in FCR has actually changed little since 2001. In contrast, in 1981 there were over 75% of farms under $100,000, compared to 56% most recently. The big decline in the number of these farms was from 1981 to 2001

- The frequency of farms between $100,000 and $500,000 in FCR increased in number between 1981 and 2001, and has since declined. This is consistent with farms previously in the <$100,000 FCR category shifting into categories between $100,000 and $500,000 between 1981 and 2001, but not much since 2001
- The farms with FCR in excess of $500,000 have increased in number since 1981, with a levelling off and slight decline in the number with FCR of $500,000 to $1,000,000.
- The growth in the frequency of farms is limited to those exceeding $1,000,000 in FCR. All other economic size categories are in decline. Farms with FCR greater than $1

million increased in number 13.5 fold between 1981 and 2016.
- Today farms with >$500,000 in FCR represent 16% of farms; those with >$2million in FCR represent 2.8% compared to 0.18% in 1981.

If the step-by-step farm structure hypothesis above were correct, then one would expect that, in the small and mid-size categories, a decline the number of farms in a given size category would be accompanied by a concurrent increase in the adjacent larger size category.

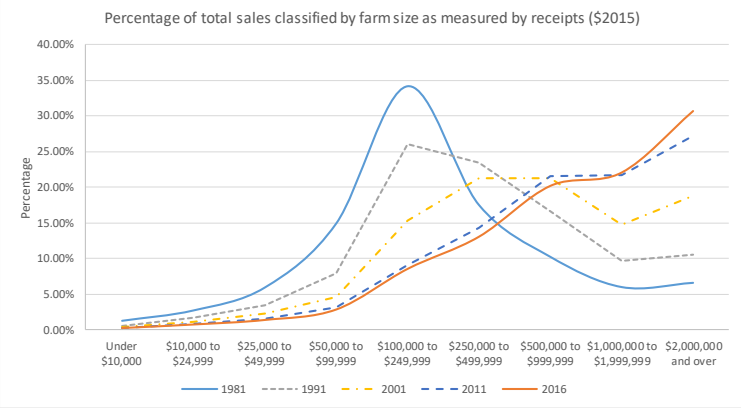
Figure 3, expanded on the last page of this note, decomposes the data in Figure 2 into census period by census period changes. It shows the following:
- In the earliest periods, the reduction in total farm numbers was borne primarily by the small farms (<$100 K)
- There is evidence of step-by-step transition in the earliest periods. For example, comparing 1991 versus 1986, the loss of farms in the $100K-250K category is almost exactly offset by growth in the $250-500K class; this is repeated again comparing 1996 versus 1991. One can see the same sort of pattern in 2006 versus 2001, but with the decline in $250-500K class largely taken up in growth in the growth of the $500K to $1 M class.
- The most recent census periods do not exhibit step-by-step movement in farm structure. Increasingly, the loss in total farms is accounted for by the mid-sized farms in the $100-250K and the $250-500K size classes
- The largest two size classes have not declined in number since the 1981 census and the very largest class is accelerating in number.

So, rather than a plodding trend, what appears to be happening is that the segment of very large farms is growing, and the declines have occurred among very small farms (and mostly some time ago) and more recently among the mid-sized farms- the net effect being an increasing average size.

How should we interpret the significance of this trend? Figure 4 relates the frequency of farms by FCR group to their economic significance in terms of shares of total FCR, adjusted for inflation. The graph is constructed by multiplying the number of farms in each size category by the midpoint of the category; for the open-ended category >$2 million in FCR, a representative value of $3 million was assumed.

The graph suggests that, in 1981, the bulk of Canadian FCR (more than one-third) was accounted for by farms with sales of $100,000 to $250,000, and the shares of farm sizes both larger and smaller than this fell steeply. This general structure is still evident in 1991 with a concentration of FCR in the mid-size, but with the "mid-size" shifting to the right to be larger, and with the shares of larger farms clearly increasing.

Figure 4: Share of Farm Cash Receipts in Canada by Economic Size, Census Years, $2015



Source: Statistics Canada. Table 004-0006 - Census of Agriculture

However, the structure with a dominant mid-size and small and large as outliers had largely disappeared by 2001, and is not evident at all by 2011. As of 2016, the bulk of FCR (around 30%) is due to the largest size of farms with FCR exceeding $2 million (only 2.8% of farms). There is no density around a mid-size as was

previously evident, and (consistent since 1981) the small farms are collectively insignificant in their share of farm economic output. In a fellows address in 2018 (discussed further below), Alfons Weersink constructed an analogous graph, and drew similar conclusions.

Data for the 2021 Canadian Census of Agriculture is currently being collected; whether these trends are altered or further reinforced will need to be examined carefully.

Economies of Size

As a capital-intensive industry, agriculture is subject to economies of size- a decrease in unit costs of production with expanding output over some range. Its sources are several and well known. Larger farms have the ability to spread out incremental costs over a much larger output and overhead structure than smaller farms do. For example, the average cost impact for a farm of 200 acres newly acquiring a parcel of 100 acres is very different than the same 100 acre parcel acquired by a farm of 3,000 acres. For the large farm the acquisition of the 100 acre parcel is at the margin; for the 200 acre farm it represents a shift of 50 percent- the impact of average land costs is quite different for the two farms. Alternatively, it is much easier to acquire a new tractor if one already has a trade-in than if the full price of the new machine must be paid, as the cash cost is the difference between new and trade-in (used) value.

Another aspect is capacity utilization. Farm equipment represents a lumpy input in which the unit cost of operations decreases with output until it approaches the capacity of a machine. Larger farms tend to be better able to more fully use machines of a given capacity, and can justify/use machinery with larger capacity. The equipment used on very large farms, e.g., air seeders, often does not come in a smaller version available for small farms. Instead of one piece of equipment used to plant, apply fertilizer, minimally cultivate and apply pesticide, small farms must use separate pieces of equipment for each of these operations. This feature contributes to size economy for farms.

Larger operations can also leverage some bargaining power with suppliers- by purchasing in volume they can avail themselves of quantity discounts not available to smaller farms. Strictly speaking, economies of size is a cost concept; however, larger farms can also leverage size advantages in marketing, through volume premiums and or preferential pricing arrangements from farm product purchases eager to access large volumes from a single supplier.

Size economies lead to higher internal rates of return for assets acquired and used by large farms versus smaller farms; this has important implications for competition between farms for durable inputs. Large and very large farms, because of economies of size, in many cases are setting the price of physical assets, normally above what smaller farms could profitably afford.

In a broad analysis of farm structure in Canada, Weersink (2018) focused on economies of size as the primary cause of increasing average farm size, and the drive to adopt improved technology motivated by the prospect of greater economies of size for large farms.[1]

Asset Fixity

Farm capacity, once established, is not readily reduced or removed. This is due to the presence of fixed costs associated with durable assets, which are better off being used than idled if farm prices/returns deteriorate. This lends an element of irreversibility to investments in farm capacity.[2]

[1] Weersink, Alfons. 2018. "The Growing Heterogeneity in the Farm Sector and Its Implications", *Canadian Journal of Agricultural Economics* 66 (2018) 27–41

[2] Extensive work by Hathaway argued that the same is true of human capital on farms with a resistance to leaving farms, even in periods of adverse returns, exacerbating low returns.

What creates this fixity is that there are effectively two prices for durable farm assets, such as farm machinery.[3] There is a new acquisition price, P_A, and a lower salvage or resale/used price, P_S. Outside of financing considerations, the feasibility of a farm acquiring a new asset relates to its internal productivity/return relative to the P_A and P_S. Provided that its internal productivity exceeds P_A a farm can justify acquiring new equipment or purchase more of it; if its internal productivity falls below P_S it will liquidate the asset to the used market. However, where internal productivity falls in the range between P_A and P_S, there is no better option than to continue to use the asset and it is effectively fixed.

This builds in some irreversibility into farm supplies- this has been extensively explored as an element of investment in capacity in agriculture, and an aspect of the *farm problem*- chronically low and unstable farm prices and returns. Essentially, the argument is that farmers invest too much in productive assets at too high a price, and in turn, this generates additional aggregate supply that depresses farm prices and adds to instability in farm incomes. This is exacerbated as commodity prices rise, because the productivity/return derived from using the asset rises above acquisition prices, encouraging new investment. When prices later fall, in many cases, the internal productivity falls between P_A and P_S, and continued use is the only option- exacerbating excess supply.

But there are other aspects. The discussion of economies of size suggests that the largest farms will tend to have the highest internal use value of durable assets, so they are best positioned to buy new equipment at P_A. Smaller farms with lower internal use values cannot justify purchasing new equipment at P_A; their only practical option to access equipment they wish to own is by buying used equipment at P_S.

However, in turn, the ability of the large farms to acquire new assets at P_A is influenced by the used market price P_S as it determines the cash value of the difference between new and used prices that they pay with trade-ins in acquiring new equipment. A decrease in the value of P_S, for a given level of internal productivity and new equipment price P_A is a disincentive for investment by the larger farms otherwise positioned to invest in new equipment.

But at the same time, the ongoing leveraging of economies of size by the large farms makes the competition for inputs increasingly difficult for smaller farms, meaning that as the larger farms invest in new equipment it pressures the ability of smaller farms to purchase at P_S. Moreover, it is well known that as the price of new equipment increases- in part due to demand pull for new equipment- it pulls the value of used equipment up with it.

Figure 5 below provides some empirical context relevant to farm machinery prices for P_A and P_S. The figure plots the Farm Input Price Index (FIPI) for machinery depreciation, machinery repairs, and the overall index for all farm inputs. One would expect machinery depreciation to be most closely tied to new equipment (priced at P_A) and parts and repairs to be more closely tied to used equipment P_S. Compared with the FIPI as a whole, both depreciation on machinery and machinery repairs have recently ranged higher. Depreciation on machinery has increased relative to the overall FIPI, and also relative to machinery repairs. This provides some evidence, equivocal in nature, that for machinery P_A may be increasing relative to P_S.

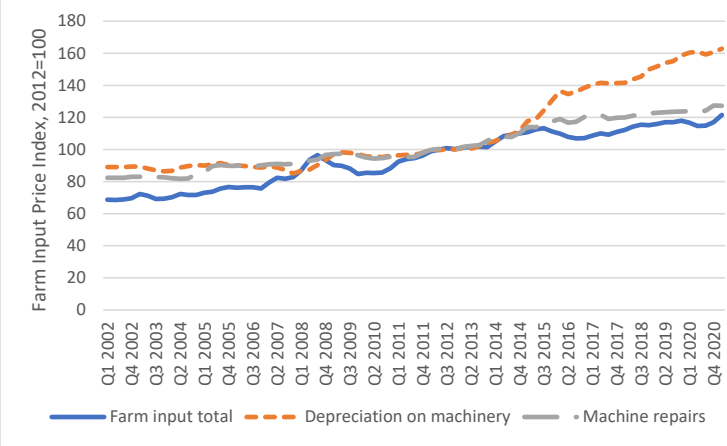
See for example Dale E. Hathaway. 1964. *Problems of Progress in the Agricultural Economy*. Chicago: Scott, Foresman and Company

[3] This section draws heavily from work pioneered by G. L. Johnson, see for example Glenn L. Johnson, "Supply Functions Some Facts and Notions," *Agricultural Adjustment Problems in a Growing Economy*, Iowa State University Press, 1956.

Better information is required on new versus used equipment markets to make any firm conclusion. However, the implication is that if the used price is weakening relative to the new price, it is both an indication that the demand for used equipment driven by smaller farms could be softening, and it would be a warning that demand/investment in new equipment could follow as the larger farms' trade-in value erodes.

Moreover, capital investments accumulate over time and are complimentary. Adoption of a new technology will depend somewhat on a farm's existing technology/equipment portfolio, accumulated over time. The farms best positioned to adopt a given new technology are the ones with an overhead structure that most easily accommodates or makes use of new technology. For example, the farms best positioned to adopt technologies like auto-steer and headland management systems in tractors are those that already have modern implement sets that these systems are designed to fit into. It is more costly, or perhaps even prohibitive, to adopt these systems into say a 40 year old set of machinery, and over time farmers with this older machinery could find themselves left behind. Smaller farms depend on new investments being made by larger farms to generate a supply of used equipment that is feasible for their operations, so the dependence is two-way. However, the data show that the dynamic has evolved in favour of the large farms, especially as the productivity of new equipment is leveraged in competition for land.

Figure 5: Farm Input Price Index, Selected Series, Canada



Source: Statistics Canada. Table 18-10-0258-01 Farm input price index, quarterly

Conclusions

The historic way of explaining how farm structure evolves no longer holds. The data for rejecting the step-by-step interpretation used in the past is clearly evident. A modified hypothesis- that increases in average farm size are essentially due to the large getting larger- can be easily supported from the data compiled by Statistics Canada. It is also consistent with Weersink, who observed that "The decline in the number of 'average-sized' farms and the growth in the number of large farms are due primarily to technological innovations that push operations producing commodities to grow as a means of capturing economies of size."[4]

Moreover, it is not clear that there was sufficient evidence to suggest that the step-by-step hypothesis was ever accurate in the past. It may be that the changes are simply more clearly evident recently.

Why do large farms continue to grow at the expense of the small? Economies of size are an important cause, especially when competition among farms is for inputs (especially land). The growing number of large farms have the size and returns to support increasing investments in machinery, which asset fixity theory tells us lends some irreversibility in farm product supplies, which in turn pressures farm prices and receipts- especially for smaller farms lacking

[4] Weersink (2018) goes on to highlight the diversity of smaller farms, and that in more recent periods the small farms have not declined in number to the same extent as the md-size farms. This same observation is borne out here.

economies of size. This has been established for some time.

But what is newly evident is that there is a critical contradiction- for the large farms to continue to invest, they need the residual demand pull for used assets from smaller farms. Yet the supply produced by the larger farms- leveraged by economies of size and asset fixity- pressures returns in the small/medium size farm segment, and makes it more difficult for the small/medium sized farms to effectively compete for land.

The implication would seem to be that that there is an "optimal" diverse size structure of farms- in which there are sufficient residual demands for farm assets from smaller farms to facilitate ongoing investment by larger farms, without the larger farms running over smaller farms through competition for land. However, competition and market action may not take us there.

There are some caveats. First, one would expect the pricing of used machinery to be strongly positively related to the pricing of new machinery. Anyone who has recently looked at purchasing used farm machinery recently probably does not have the impression that the demand has collapsed. However, the demographics underlying this demand certainly serve to undermine rather than strengthen demand.

Secondly, there are risks and inaccuracies to a stereotype or contrast between large farms as more efficient than smaller farms. The key differentiator is management and there is an old adage in farm management research that there is more variation in returns within farm size categories than across farm size categories (even with economies of size). Some confirmation of this has come from research in Canada.[5] Larger farms can have operating advantages, but be financially leveraged and lack financial capacity of smaller farms with exceptionally strong balance sheets. It also implicitly invokes the assumption of commodity-based agriculture and a low-cost strategy, when alternative strategies such as niches exist that fit better with farms lacking size economies- as identified by Weersink.

There are also differences when the data are fragmented by farm/commodity type and province. This suggests that national approaches to policy regarding farm structure would be difficult to design or execute with likely strongly conflicting views by commodity, region/province and municipalities.

However, these are sub-trends within broader aggregate trends, and economies of size are a source of competitive advantage under virtually all strategies (not just low-cost) and across commodities and provinces. Virtually all farm types compete for land and have equipment as an important component of their cost structure.

If large farms are growing at the expense of smaller farms, but also doing so to their own detriment, is it a policy issue? It would be hard to argue that it is not. Large and highly efficient farms are a lynchpin in competitive agri-food supply chains; smaller farms are linked to the development and sustainability of rural communities.

Policy objectives for farm structure do not exist, let alone programming. By default, policy-related discussions on farm structure gravitate to extremes- encourage the largest and most efficient; or, conversely protect/restore the small farms. The linkage between the two extremes, or the more general dependence within distribution of farm sizes observed here, is never raised.

If farm structure is a policy issue, what types of policy instruments are available? Caps on farm program

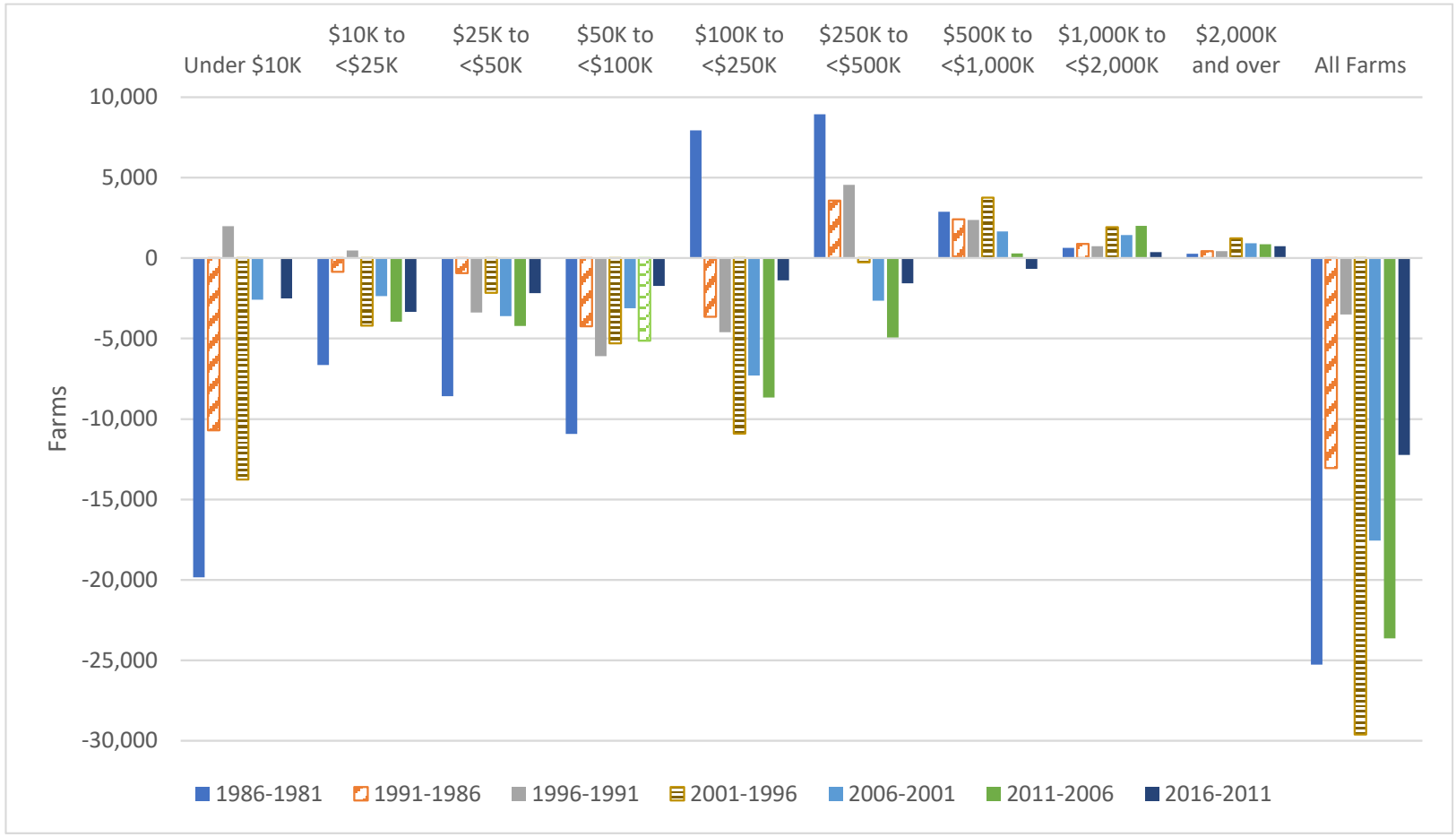
[5] Mussell, Al, Terri-lyn Moore, Ken McEwan, and Randy Duffy. "Understanding the Structure of Canadian Farm Incomes in the Design of Safety Net Programs", *Canadian Journal of Agricultural Economics* 55(4) 565-586. December, 2007.

payments are not intended to address matters of structure; rather they target the perception of "corporate welfare" and large payments to large farms. Municipal policies that deal with land use taxation, etc., can apply differentially across farm sizes, but it is unclear how this could be coordinated or coalesced into a national, or even broad provincial agenda. It is unclear that there are policy instruments that address structural issues directly.
At the same time, the Hippocratic Oath to "at least do no harm" warrants observation in thinking about policy prescriptions that address shifting farm structure. While these dynamics may be periodically observed in the farm community, broadly speaking farm groups are not requesting policy action here, and governments may not look favorably on the prospect of industrial engineering in primary agriculture.

However, if the implications drawn from the data presented here are correct, they should not be ignored. The understanding and assumptions of economic demographics in primary agriculture anchor discussions and designs of everything from agribusiness retail, to governance of rural municipalities, to business risk management programming.

What this interpretation of the data is telling us is that wide swaths of farms are being left behind-previously viewed as viable family businesses- in the wake of rapid growth in the large and very large segments. The process seems to be happening at such a rate that it threatens to cannibalize itself, eventually slowing down with the decline in residual demand for assets. In turn, a slowdown in investment by large farms presents a threat to Canada's agri-food competitiveness. This presents a conundrum to the agri-food sector and agri-food policy that warrants broad awareness and further research and discussion.

Figure 3: Change in Numbers of Farms by Farm Cash Receipt Class (in 2015 $'s), Census Period by Census Period



Source: Adapted from Statistics Canada. Table 32-10-0157-01 Farms classified by total gross farm receipts, 2015 constant dollars, historical data