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Abstract

We estimate the impact of the 2012 removal of the Canadian Wheat Board's (CWB) single-desk on the spatial pattern of durum wheat acres in Western Canada. We analyze changes in durum seeded acres with a panel regression and Census Agricultural Region data from 2004–2016. Our results indicate that removal of the CWB single-desk had a significant impact on total durum production in Western Canada. In addition, we find that the spatial distribution of durum wheat acres shifted towards drier areas, an improvement in the efficiency of resource allocation.

JEL Classification Codes: L43, Q17, Q18, R12, R14

Keywords: state trading enterprises, deregulation, agricultural regulation, comparative advantage

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Canada is the world's largest producer and exporter of durum wheat. In a typical year, durum accounts for about 20% of prairie wheat acreage (AAFC 2019). Canada Western Amber Durum (CWAD) is high in protein and gluten and is used primarily for making semolina flour, which is made into pasta and couscous.[1] For over 70 years, until August 1, 2012, the Canadian Wheat Board (CWB) had exclusive control over the purchase and sale of durum wheat produced in western Canada for human consumption or export.

Domestic and international political pressure led to removal of the CWB's monopoly/monopsony powers in 2012. By then state trading enterprises (STEs) like the CWB had come under increased scrutiny by members of the World Trade Organization (WTO). At the same time, the benefit of the CWB single-desk was being debated within Canada and some farm groups on the prairies wanted the freedom to sell their own wheat. In this paper we measure the extent to which removal of the CWB single-desk affected total durum acreage and the regional location of durum acres on the prairies. Certain regions of the prairies are better suited to producing durum (a high-quality wheat) and we have found that acreage has shifted to those areas in the deregulated marketplace.

During its heyday, the CWB was arguably the most influential institution in Canadian agriculture. CWB decisions, regulations, and institutional arrangements influenced agricultural resource allocation throughout the Canadian prairies, even for crops that were marketed outside the CWB. All aspects of the production, storage, transportation, processing and marketing of grains were influenced by the CWB. Under the CWB system, farm and grain industry decision making was typically in response to non-market incentives (Carter, Loyns and Berwald, 1998), leading to production and marketing inefficiencies.

[1] According to the USITC (2003) once a minimum protein level is achieved for durum wheat, additional protein content has little or no value. "The most desirable characteristics for durum wheat are a high vitreous kernel content, a golden colour, consistent sizing, and a lack of damage and contamination."

This paper builds on existing literature on deregulation and gains from specialization, which has been found in the context of agriculture (Dries and Swinnen, 2002; Carter and Ferguson, 2019), manufacturing (Eslava et al, 2010; Alfaro and Chari, 2014), fisheries (Salvanes, 1993) and oil production (Asker et al., 2018). In addition, there is a growing literature that has studied the misallocation of production due to domestic policy distortions, which has been shown to have significant quantitative impacts on aggregate efficiency (Hsieh and Klenow, 2009; Adamopoulos and Restuccia, 2014).

Our study also contributes to a new branch of the literature evaluating the ex post economic impact of the removal of STE powers.[2] Carter and Ferguson (2019) found that malt barley production became more concentrated around malt plants after the end of the Canadian single desk. Other ex-post evaluations have focused on the impact on the export basis, pointing to deficiencies in post-CWB Western Canadian grain transportation policy. Serfas et al. (2018), Torshizi and Gray (2018) and Slade and Gray (2019) provide evidence suggesting that the export basis widened in years with large crops. They attribute this result to a lack of export capacity and an imbalance in market power between grain companies and farmers.

Durum Marketing on the Prairies before and after Deregulation

Durum wheat seeded acreage in Alberta, Saskatchewan and Manitoba averaged 4.7 million acres per year during the 2004–2015 period, making it the fifth largest prairie crop during this time.[3] Of the 4.8 million tonnes of durum produced per year on average, approximately 200–250 thousand tonnes was processed domestically for human consumption, and the rest was exported or fed to domestic livestock.[4]

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[2] Many studies of the economic impact of the CWB were performed without data on post–reform outcomes, see Veeman, 1987; Alston et al., 1993; Carter et al., 1998; Furtan et al. (1999); Alston and Gray, 2000; Carter and Smith, 2001; Lavoie, 2005; McCorriston and MacLaren, 2006; Tamini, et al 2010; Bekkerman et al., 2014. In contrast to work by Furtan et al. (1999) and Lavoie (2005), who focused on price impacts of the CWB and argued that they found price premiums, we focus on the impact on seeded area, which has received less attention in the literature.

[3] Field Crop Reporting Series, Statistics Canada.

[4] The supply and disposition of Western Canadian Durum Wheat is provided in Table A1 in the Appendix.

All wheat (including durum wheat) sold for human consumption at home or abroad had to be sold via the CWB prior to its removal.

One principle of the CWB system was to provide equitable access to markets for all producers. During the period we study, producer sales of grain to the CWB were regulated through individual producer "contracts." Under these contracts, producers offered to sell a certain quantity of wheat[5] to the CWB and then the CWB would, in turn, announce the quantity and quality of wheat that they were willing to accept, which could be less than the amount offered. During the "crop year" (August 1st – July 31st) the CWB would then issue "delivery calls" requesting that certain durum wheat be delivered by the producer.

A fundamental characteristic of the CWB single-desk system was "price pooling" whereby all producers were paid the average price received by the CWB in the durum pool for a given crop year, net of the CWB's operating and marketing costs. Under the delivery contracts, farmers delivered their grain to a primary elevator when called in by the CWB, and then they received an initial payment upon delivery, based on the wheat grade. In some years, producers received an interim payment during the crop year and then a final payment about five months after the crop year was over. After the end of the crop year the pool was closed, and the CWB deducted its administrative expenses, interest costs, and other allowable expenses. Each producer received the same price (before export basis deductions)[6].

Since 2000 the CWB started offering producers various alternative ways to price outside the pool through various pricing contracts.[7] Outside the pool, producer payment options included fixed price contracts (FPC), basis price contracts (BPC), and daily prices-called FlexPro (CWB 2010–2011 Annual Report, p.87). The FPC

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[5] CWB 2011-12 Wheat Delivery Contract Terms and Conditions. Available at http://www.g3.ca/_uploads/documents/wheat2_tc.pdf

[6] The export basis at each delivery location on the prairies was determined by a combination of the railway freight cost per tonne to either Vancouver or Thunder Bay, and also a Freight Adjustment Factor (FAF). The FAF deductions cover a portion of the costs of moving grain to the east coast that are in addition to the rail freight costs of shipping to Thunder Bay (CWB 2011). The FAF was a regulatory tool used by the CWB with the stated goal to create an export basis at each location that more closely reflected true local demand.

[7] World Trade Organization, State Trading: Canada, G/STR/N/CAN, July 6, 2012.

and BPC offered the fixing of the price or basis (respectively) for sign-up by January 31. Alternatively, FlexPro offered a daily spot price, provided that the volume was assigned before the beginning of the crop year. It turned out that these contracts were not attractive to durum producers, evidenced by the fact that few farmers signed up for them. For instance, in 2009–2010 only 18 farmers signed up for FPC/BPC/FlexPro durum contracts, representing 3,328 metric tons. In 2010–2011, only 15 farmers signed up, committing a tiny volume of 1,353 metric tons (CWB 2010-2011 Annual Report, p.54).

Problems with the restrictive and bureaucratic nature of the CWB single-desk system were highlighted with the 2008–09 and 2009–10 crop years. In both those years the CWB failed to accept all of the durum wheat offered by the producers. In 2009–10 the CWB only accepted 40% of Series A (expiring October 31st) and 20% of Series B (expiring January 31st) durum contracts (CWB 2009–10 Annual Report, p. 56). Since the balance of the Series A (60%) was rolled into series B, the net call on Series B was 12% of the crop. Therefore, on net, the CWB only accepted 52% of the volume of durum offered for sale that year by prairie growers. At the time, there was concern that the CWB might incur a deficit in the 2009–10 durum pool and therefore it presumably stopped accepting producer deliveries. As a result, producers were either forced to keep their durum in storage or sell it into the lower priced feed market to generate some cash flow. As shown in Table A1 in the Appendix, both feed usage and ending stocks in 2009–10 doubled from the previous year. On farm stocks ended up exceeding 40% of annual use.

The CWB's authority to sell wheat and barley on behalf of growers officially ended on August 1st, 2012 with the passage of Bill C-18, also known as the Marketing Freedom for Grain Farmers Act (2011). Producers are now free to contract with domestic or foreign durum mills, or with grain merchants. Durum is now marketed through spot sales or forward contracting. The restrictive nature of the single-desk system, such as experienced in 2009–10, when farmers could only sell one-half of their durum wheat, was now gone.

Durum wheat is well-suited to more arid regions of the Canadian Prairies (Sask Wheat, 2019), and production is mainly concentrated in southern Saskatchewan and southern Alberta. Durum production in wetter areas of the Prairies also occurs, although crop quality tends to be lower.[8] In some years the expected price for durum was sufficiently high compared to spring wheat that some farmers in marginal durum-growing regions chose to take the risky strategy of growing durum. Growing both durum and spring wheat also was seen as a way to diversify risk.

The risky strategy of growing durum in less ideal areas was encouraged by CWB policy for two main reasons. First, the prices at each delivery location under the CWB system did not necessarily reflect true demand. Second, under the CWB system, all country elevators were required to accept delivery of durum wheat, even in regions of the prairies poorly suited to growing durum, with associated low quality and small volumes. Even though handling small durum volumes was highly inefficient, grain companies acting as agents of the CWB could not decline delivery or provide price signals that would incentivize farmers to grow spring wheat instead. After the removal of the CWB single-desk, grain companies were no longer compelled to take delivery of durum at all elevator locations, and many elevators stopped buying durum altogether in regions poorly suited to the crop.[9] This practice discouraged farmers from growing durum in wetter areas.

Data and Descriptive Statistics

Our main data source is the Field Crop Reporting Series, which is published annually by Statistics Canada.[10] The Statistics Canada survey collects information on seeded and harvested area of field crops, production, average yields and on-farm stocks over the course of the growing season. We focus on seeded area because it

[8] Personal communication, Geoff Backman, Alberta Wheat Commission, May 2, 2019.
[9] Personal communication, Geoff Backman, Alberta Wheat Commission, May 2, 2019.
[10] See http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3401 for more information.

most accurately reflects farmer's production decisions and is not influenced as much by weather during the growing season.

The data on seeded area is published for each Small Area Data Region. We study the provinces of Alberta, Saskatchewan and Manitoba, and prior to 2017 each Small Area Data Region corresponded to a Census Agricultural Region (CAR).[11]

The average area seeded to durum in each CAR during the 2004–2011 period is illustrated in Figure 1. This map shows that durum wheat production was concentrated in southwest Saskatchewan and southeast Alberta, which are the most arid parts of the Canadian prairies. We also illustrate changes in durum wheat acreage across CARs "before versus after" the CWB regime in Figure 2. This map shows that after deregulation there was a distinct increase in durum wheat acreage in the areas that were already specialized in durum. In contrast, durum wheat acreage in other parts of the prairies declined.

In order to explain seeded acres, we include weather averages within each CAR as control variables, both annual and long-run averages. The annual weather data is from the University of East Anglia (Harris et al. 2014). The 1961–1990 climate averages are based on the "historical and projected climate data for North America" (ClimateNA) data based on methodology described by Wang et al. (2016).[12]

As additional controls we use the average pre-season (January to April) prices for durum and spring wheat as proxies for expected fall prices. We use the spot price for durum wheat and the November futures price for spring wheat, both taken from the Minneapolis Grain Exchange and converted to Canadian dollars. The durum spot price data are available back to 2004.

The prairie crop region boundaries are geographically consistent until 2016, which restricts our study to the 2004–2016 period. This 13-year period provides us

[11] In 2017 the Field Crop Reporting Series switched from using CAR boundaries to using Census Division boundaries for Saskatchewan. We therefore cannot perform our analysis at the regional level using data for 2017 and onward.

[12] The climate average data has been generated with the ClimateNA v5.10 software package, and is available at http://tinyurl.com/ClimateNA.

with several years before and after the 2012 reform. There are 30 CARs that report positive durum wheat acreage more than one year during the 2004–2016 study period. The panel is unbalanced, as several durum wheat observations have been censored.[13] We are thus left with 311 non-missing observations on seeded acres in our analysis, of which 45 take a value of zero.

The Impact on Total Durum Wheat Production

We first study the impact of the removal of the CWB on total durum wheat acreage. Our methodology takes the form of a panel Poisson regression with panel fixed effects. The Poisson approach allows us to include the zero production observations that sometimes occur in marginal durum growing areas. We employ the following specification for measuring the effect of the removal of the CWB single-desk on durum seeded acreage in each CAR:

$$durum\_acres_{it} = \alpha + \beta(postCWB_t) + \gamma_1(weather_{it}) + \gamma_2(prices_t) + \delta_i + \varepsilon_{it}, \quad (1)$$

where $durum\_acres_{it}$ are the acres seeded to durum wheat in CAR i in year t, in thousands. $postCWB_t$ is an indicator variable taking a value of 1 for the years 2012-2016 and zero otherwise.[14] $weather_{it}$ is a vector of weather controls that vary over time and location, We include three annual weather controls: summer (June to August) precipitation from the previous year in mm, pre-season (January to May) precipitation in mm, and summer (June to August) mean temperature from the previous year in Celsius. We hypothesize that a wet or cool growing season in the previous year or a wet spring would discourage farmers from seeding durum wheat.

[13] The Field Crop Reporting Series reports acreage always reports total wheat acreage (spring + durum + winter wheat). In many cases, the winter wheat observations are censored due to a lack of sufficient survey participants reporting winter wheat production for a given CAR and year. Since the total wheat acreage is always reported, acreage for a second wheat type the same year and CAR must also be censored (often durum wheat) in order to ensure that winter wheat acreage cannot be backed out from the data. We treat these occurrences as missing data. If durum wheat is missing, but spring wheat + winter wheat = total wheat, then we treat the observation as a zero.
[14] Durum wheat grown in the summer of 2012 was subsequently sold during the 2012-13 crop year, which constitutes the first post-reform year.

$prices_t$ includes the proxies for the expected prices for durum and spring wheat. We hypothesize that seeded acres of durum wheat will respond positively to expected durum prices, and negatively to expected prices for alternative crops such as spring wheat. δ_i denote CAR fixed effects. The CAR fixed effects account for much of the geographical variation across CARs that explain durum wheat acreage, such as long-term climate averages and soil characteristics.

The main regression results are presented in Table 1. All columns of Table 1 include CAR fixed effects. In column (1) we include only the dummy variable for the post-reform period, $postCWB_t$. In column (2) we include the time-varying weather controls, and in column (3) we include the durum and spring wheat price controls. In column (4) we include all controls.

The point estimate for $postCWB_t$ is positive and statistically significant at the 1 percent level in all columns of Table 1. The regression coefficient for $postCWB_t$ in column (4) suggests that the elimination of the CWB monopoly led to a $(e^{0.14} - 1) \times 100 \approx 15$ percent increase in durum wheat acreage. Given that the area seeded to durum during the pre-reform 2004–2011 study period averaged 4.7 million acres per year, this translates into an increase of 700 thousand acres per year in the immediate post-reform time period.

Pre-season precipitation had a positive and statistically significant effect on durum seeded acres. This may be driven by farmers choosing to grow durum instead of summer fallowing in years where soil moisture is plentiful in the spring.[15] Precipitation during the previous summer had a statistically significant impact on durum acreage, while average temperatures during the previous summer did not have an impact. Pre-season durum prices had a positive and statistically significant effect on durum seeded area, while spring wheat futures prices had a negative and statistically significant effect. A positive own-price elasticity and negative cross-price elasticity are both in line with our expectations.

[15] Summer fallowing is the practice of leaving the land to lie fallow one year for the purpose of accumulating soil moisture. Although the practice of summer fallowing has declined over time in favour of continuous cropping, this practice was still quite common in more arid parts of the prairies, the same locations where durum wheat is prevalent.

Comparing production *before versus after* the elimination of the CWB precludes us from controlling for unobserved annual variation using year fixed effects here, which is a limitation of the regressions based on equation (1). However, we include year fixed effects when studying the spatial distribution of durum wheat production in the next section, since the coefficients of interest are interactions of the CWB indicator with climate and geography variables.

The Impact on the Spatial Distribution of Durum Wheat Production

We now study heterogeneity in the impact of the removal of the CWB, specifically how it differentially affected durum wheat acreage in wetter versus drier areas of the prairies. We also use a panel Poisson regression with fixed effects, but we now include interactions of the reform indicator variable with long-run climate averages. We employ the following specification, based on equation (1):

$$durum\_acres_{it} = \alpha + \beta(postCWB_t \times climate_i) + \gamma_1(weather_{it}) + \gamma_2(prices_{it}) + \delta_i + \delta_t + \varepsilon_{it}. \quad (2)$$

Note that we include year fixed effects δ_t, which control for any unobserved year-specific covariates. The year fixed effects thus subsume the CWB indicator variable and the price controls. Our main coefficients of interest are the interaction of the post-CWB dummy with long-run climate averages, $postCWB_t \times climate_i$. We include interactions with three long-run climate variables: summer (June to August) precipitation in mm, climatic moisture deficit (based on the Hogg 1997 modified Penmnan-Monteith method), and summer (June to August) mean temperature. We include CAR fixed effects and the same time-varying annual weather controls as we used in equation (1). If areas of the prairies with a typically drier climate grew relatively more durum wheat in the post-CWB environment compared to typically wetter areas, we would expect a negative sign on the $postCWB_t \times precip_i$ interaction term.

The regression results when interacting CWB reform with climate averages are presented in Table 2. In column (1) we include the interaction between the post-CWB indicator and summer precipitation, $postCWB_t \times precip_i$. We find a negative and statistically significant point estimate on this interaction term, which indicates that durum wheat acreage rose relatively more in drier regions after the end of the CWB. The regression coefficient for $postCWB_t \times precip_i$ in column (1) suggests that a region with long-run precipitation 10mm below the mean led to an additional $(e^{0.0071} - 1) \times 10 \times 100 \approx 7$ percent increase in durum wheat acreage due to the reform. Similarly, an area with long-run precipitation 10mm above the mean reduced their durum acreage by 7 percent compared to the average.

In column (2) of Table 2 we include the interaction between the post-CWB indicator and the drought index, $postCWB_t \times drought_i$. We find a positive and statistically significant point estimate on this interaction term, which suggests that durum wheat acreage increased relatively more in the arid regions once the CWB monopoly was removed. The results suggest that drier areas grew relatively more durum after the reform, and wetter areas grew relatively less durum.

In column (3) of Table 2 we include the interaction between the post-CWB indicator and summer mean temperature, $postCWB_t \times temp_i$. We find no statistical significance on this interaction term, which agrees with our earlier findings showing that durum acreage is unresponsive to lagged annual temperature.

We include annual weather controls in all columns of Table 2. Summer precipitation or average temperature in the previous year did not have a statistically significant impact on durum acreage, and pre-season precipitation had a weakly negative effect on durum seeded acres.

Further Results and Robustness

We check whether our main results are robust to including additional control variables. We first check whether our results in Tables 1 and 2 are robust to using an alternative dependent variable, durum seeded acres as a percent of total acreage in crops or fallow. Using shares controls for changes in total area devoted to crop production on durum acreage, which could potentially be driving our results. The regression results using the percentage of durum acreage as the dependent variable are reported in Tables A2 and A3 in the Appendix. In Table A2, we find that the percentage of total acreage devoted to durum increased after the end of the CWB monopoly, which agrees with our main findings in Table 1. In Table A3, we find that the interactions of the CWB reform dummy variable with long-run precipitation and with the drought index are statistically significant and with the same sign as Table 2.

We also check whether regional differences in the export basis were an important factor in explaining growth in durum acreage in the post-CWB environment. Ferguson and Olfert (2016) and Brown et al. (2018) find, for example, that regions furthest from seaport shifted away from wheat and towards high-value crops in response to the 1995 removal of a railway transportation subsidy. The results are reported in column (4) of Table 2. We proxy the effect of freight rates adjusted by the FAF using the distance from a CAR to its nearest seaport, either Vancouver or Thunder Bay. We find that the $postCWB_t \times port\_dist_i$ interaction term is not statistically significant.

We also check whether our results on the climate interactions are robust to controlling for interactions between regional climate averages and annual durum prices. Climate variables are correlated with a region's suitability for growing durum, so that the interaction with prices arguably captures part of the impact of expected revenue per acre on the seeding decision. The regression results are reported in Table A4. We find that the results for the interactions with summer precipitation and drought are robust to including interactions with durum prices. Finally, we check if our results in Tables 1 and 2 are robust to using a linear OLS regression, with the results presented in Tables A5 and A6 in the Appendix. Our main results are very similar using the linear OLS approach. Therefore, we are confident that overall our results are robust to a wide variety of alternative regression specifications.

Conclusion

At one time, the Canadian Wheat Board (CWB)—a government agency—was one of the largest wheat traders in the world. However, like its sister agency, the Australian Wheat Board, the CWB was deregulated for various reasons, including pressure from the WTO and from domestic farmers who wanted the freedom to market their own crops. The deregulation meant that it was no longer compulsory for growers in the prairie region of Canada to sell their durum wheat to the CWB. The removal of the CWB's statutory marketing authority in 2012 provides an opportunity to measure the impact of that deregulation on the production of Western Canadian durum wheat.

In this paper we found that CWB single-desk deregulation encouraged growers in drier areas to increase durum production relative to growers in other regions. Overall, durum acreage increased as Canada clearly has a comparative advantage in producing high quality durum with consistent quality characteristics. Canada is the world's largest producer and exporter of durum wheat and this paper provides evidence that deregulation has led to a more efficient allocation of acreage in the prairie region.

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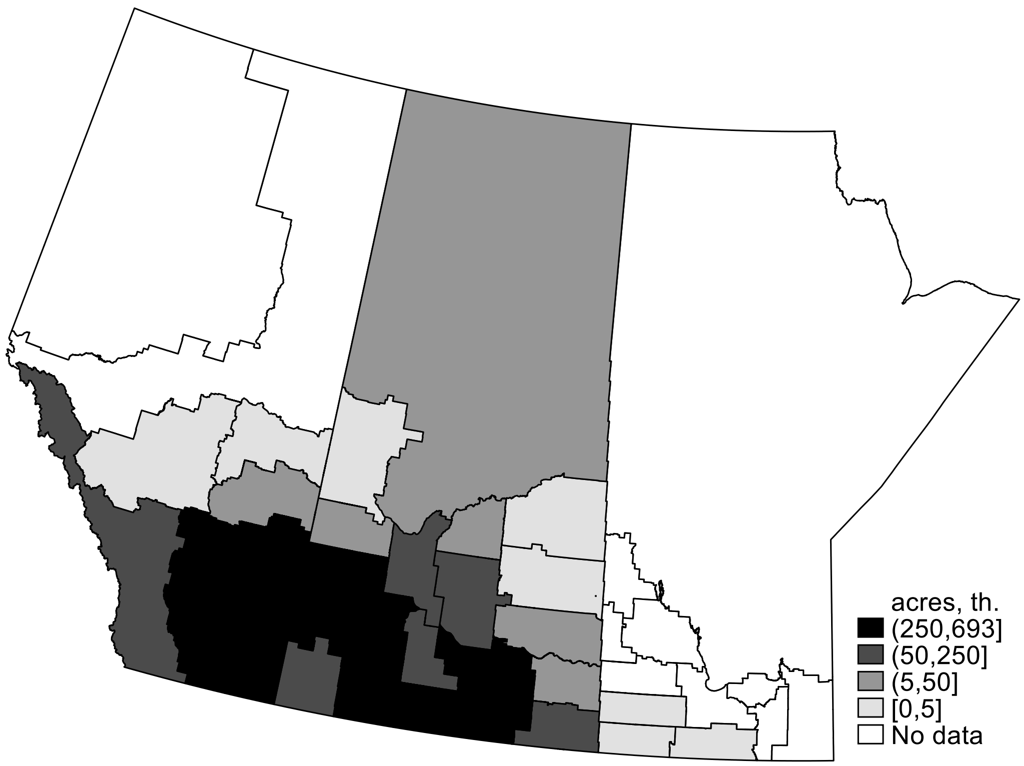

Figure 1: Durum wheat seeded area, 2004–11 average for Census Agricultural Regions in Alberta, Saskatchewan and Manitoba, in thousands of acres. Source: Statistics Canada, Authors calculations.

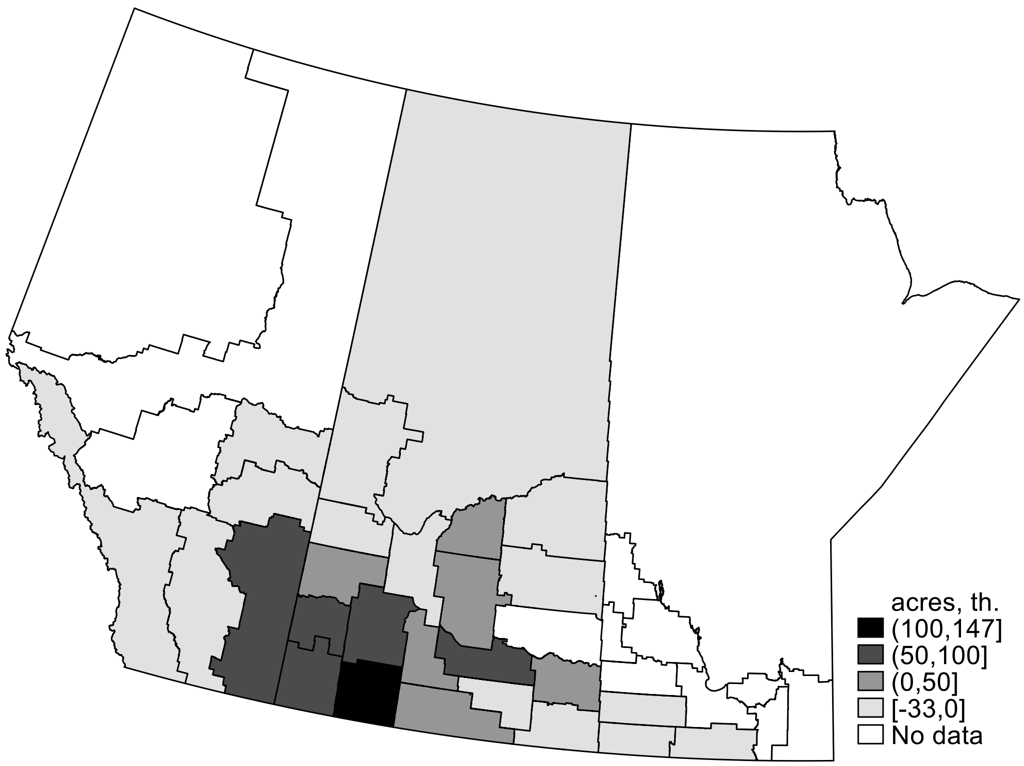

Figure 2: Change in durum wheat seeded area between 2004–11 and 2012–16 for Census Agricultural Regions in Alberta, Saskatchewan and Manitoba, in thousands of acres.
Source: Statistics Canada, Authors calculations.

Table 1: The Impact on Total Durum Wheat Production

	Annual panel, 2004-2016			
Dep. var.:	Durum seeded acreage, thousands: *durum_acres*$_{it}$			
	(1)	(2)	(3)	(4)
postCWB$_t$	0.097***	0.11***	0.12***	0.14***
	(0.033)	(0.038)	(0.039)	(0.036)
summer_precip$_{t-1}$		-0.0030*		-0.0032**
		(0.0017)		(0.0015)
pre-season_precip$_t$		0.0013***		0.00078**
		(0.00042)		(0.00032)
summer_temp$_{t-1}$		0.0058		-0.0093
		(0.020)		(0.014)
durum_price$_t$			0.059***	0.057***
			(0.0089)	(0.0097)
wheat_price$_t$			-0.085***	-0.081***
			(0.021)	(0.022)
CAR fixed effects	YES	YES	YES	YES
Observations	311	311	311	311
Pseudo R-squared	0.95	0.96	0.96	0.96
Number of CARs	30	30	30	30

Notes: This table reports the results of estimating regression equation (1). Bootstrapped standard errors in parentheses, using 200 replications. *** p<0.01, ** p<0.05, * p<0.1

Table 2: The Impact on the Spatial Distribution of Durum Wheat Production

	Annual panel, 2004-2016			
Dep. var.:	Durum seeded acreage, thousands: $durum\_acres_{it}$			
	(1)	(2)	(3)	(4)
$postCWB_t*precip_i$	-0.0071**			
	(0.0031)			
$postCWB_t*drought_i$		0.0027***		
		(0.0011)		
$postCWB_t*temp_i$			0.047	
			(0.070)	
$postCWB_t*port\_dist_i$				0.00027
				(0.00024)
$summer\_precip_{t-1}$	-0.0037	-0.0039	-0.0025	-0.0025
	(0.0026)	(0.0025)	(0.0024)	(0.0025)
$pre\text{-}season\_precip_t$	-0.00071*	-0.00083*	-0.00088*	-0.00092**
	(0.00042)	(0.00044)	(0.00053)	(0.00047)
$summer\_temp_{t-1}$	0.047	0.042	0.028	0.025
	(0.041)	(0.034)	(0.039)	(0.045)
CAR fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
Observations	311	311	311	311
Pseudo R-squared	0.98	0.98	0.98	0.98
Number of CARs	30	30	30	30

Notes: This table reports the results of estimating regression equation (2). Bootstrapped standard errors in parentheses, using 200 replications. *** p<0.01, ** p<0.05, * p<0.1

Appendix

Table A1: Durum Wheat Supply and Disposition, Western Canada (Alberta, Saskatchewan and Manitoba), by Crop Year (August 1-July 31)

Crop Year	2004/ 2005	2005/ 2006	2006/ 2007	2007/ 2008	2008/ 2009	2009/ 2010	2010/ 2011	2011/ 2012	2012/ 2013	2013/ 2014	2014/ 2015	2015/ 2016
						Thousand Tonnes						
Beginning stocks on farms	700	1005	1640	300	40	835	1975	735	400	245	725	365
Production	4801	5915	3346	3681	5519	5400	3025	4172	4627	6505	5193	5389
Grain exports	3174	4226	4432	3129	3603	3786	3274	3558	4223	5050	5152	4498
Product exports	44	47	47	46	38	34	29	25	22	21	25	16
Human food	254	248	257	229	236	261	255	232	231	236	201	209
Seed requirements	220	146	184	232	218	121	154	180	191	183	224	239
Animal feed, waste and dockage	397	460	445	493	229	506	474	270	351	405	359	312
Disposition	4090	5127	5364	4129	4324	4708	4186	4266	5018	5894	5960	5274
Ending stocks on farms	1005	1640	300	40	835	1975	735	400	245	725	365	480
Farm Stocks/Use	25%	32%	6%	1%	19%	42%	18%	9%	5%	12%	6%	9%

SOURCE: Statistics Canada, Supply and disposition of grains in Canada, Table: 32-10-0013-01

Table A2: Robustness: The Impact on the Percentage of Land Seeded to Durum

	Annual panel, 2004-2016			
Dep. var.:	Durum share of seeded area in crops or fallow, *p_durum*$_{it}$			
	(1)	(2)	(3)	(4)
postCWB$_t$	0.14***	0.15***	0.15***	0.17***
	(0.032)	(0.034)	(0.034)	(0.028)
summer_precip$_{t-1}$		-0.0038***		-0.0039***
		(0.0014)		(0.0011)
pre-season_precip$_t$		0.0015***		0.0010***
		(0.00034)		(0.00031)
summer_temp$_{t-1}$		-0.019		-0.031***
		(0.014)		(0.0089)
durum_price$_t$			0.054***	0.051***
			(0.0070)	(0.0077)
wheat_price$_t$			-0.074***	-0.068***
			(0.014)	(0.015)
CAR fixed effects	YES	YES	YES	YES
Observations	311	311	311	311
Pseudo R-squared	0.74	0.75	0.75	0.75
Number of CARs	30	30	30	30

Notes: This table reports the results of estimating regression equation (1). Bootstrapped standard errors in parentheses, using 200 replications. *** p<0.01, ** p<0.05, * p<0.1

Table A3: Robustness: Interactions, Percentage of Land Seeded to Durum

	Annual panel, 2004-2016			
Dep. var.:	Durum share of seeded area in crops or fallow, p_durum_{it}			
	(1)	(2)	(3)	(4)
$postCWB_t*precip_i$	-0.0066***			
	(0.0021)			
$postCWB_t*drought_i$		0.0026***		
		(0.00080)		
$postCWB_t*temp_i$			0.040	
			(0.059)	
$postCWB_t*port\_dist_i$				0.00040
				(0.00026)
$summer\_precip_{t-1}$	-0.0054*	-0.0054**	-0.0040	-0.0039
	(0.0028)	(0.0027)	(0.0026)	(0.0026)
$pre\text{-}season\_precip_t$	-0.00054	-0.00065	-0.00071	-0.00085*
	(0.00051)	(0.00051)	(0.00051)	(0.00049)
$summer\_temp_{t-1}$	0.0022	-0.0022	-0.017	-0.018
	(0.038)	(0.035)	(0.038)	(0.031)
CAR fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
Observations	311	311	311	311
Pseudo R-squared	0.76	0.76	0.76	0.76
Number of CARs	30	30	30	30

Notes: This table reports the results of estimating regression equation (2). Bootstrapped standard errors in parentheses, using 200 replications. *** p<0.01, ** p<0.05, * p<0.1

Table A4: Robustness to durum price interactions

	Annual panel, 2004-2016			
Dep. var.:	Durum share of seeded area in crops or fallow, p_durum_{it}			
	(1)	(2)	(3)	(4)
$postCWB_t*precip_i$	-0.0072***			
	(0.0027)			
$durum\_price_t*precip_i$	0.00010			
	(0.00025)			
$postCWB_t*drought_i$		0.0028**		
		(0.0011)		
$durum\_price_t*drought_i$		-0.000044		
		(0.000092)		
$postCWB_t*temp_i$			0.048	
			(0.061)	
$durum\_price_t *temp_i$			-0.0021	
			(0.0058)	
$postCWB_t*port\_dist_i$				0.00027
				(0.00022)
$durum\_price_t$ $*port\_dist_i$				8.9e-06
				(0.000031)
$summer\_precip_{t-1}$	-0.0038	-0.0040	-0.0025	-0.0024
	(0.0025)	(0.0025)	(0.0024)	(0.0025)
$pre\text{-}season\_precip_t$	-0.00065	-0.00077*	-0.00085*	-0.00097**
	(0.00046)	(0.00045)	(0.00046)	(0.00048)
$summer\_temp_{t-1}$	0.051	0.046	0.027	0.027
	(0.037)	(0.040)	(0.043)	(0.042)
CAR fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
Observations	311	311	311	311
Pseudo R-squared	0.98	0.98	0.98	0.98
Number of CARs	30	30	30	30

Notes: This table reports the results of estimating regression equation (2). Bootstrapped standard errors in parentheses, using 200 replications. *** p<0.01, ** p<0.05, * p<0.1

Table A5: The Impact on Total Durum Wheat Production, Linear OLS

	Annual panel, 2004-2016			
Dep. var.:	Durum seeded acreage, thousands: *durum_acres*$_{it}$			
	(1)	(2)	(3)	(4)
postCWB$_t$	20.5**	21.3**	25.2**	27.1**
	(8.83)	(9.30)	(9.52)	(9.97)
summer_precip$_{t-1}$		-0.33		-0.65*
		(0.34)		(0.34)
pre-season_precip$_t$		0.29**		0.27**
		(0.12)		(0.11)
summer_temp$_{t-1}$		3.30		-0.92
		(3.65)		(3.40)
durum_price$_t$			12.4***	12.2***
			(2.71)	(2.76)
wheat_price$_t$			-18.4***	-16.8***
			(4.28)	(4.71)
CAR fixed effects	YES	YES	YES	YES
Observations	311	311	311	311
R-squared	0.03	0.05	0.17	0.20
Number of CARs	30	30	30	30

Notes: This table reports the results of estimating regression equation (1) using a linear OLS. A constant is included, but not reported, in all specifications. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A6: The Impact on the Spatial Distribution of Durum Wheat Production, Linear OLS

	Annual panel, 2004-2016			
Dep. var.:	Durum seeded acreage, thousands: *durum_acres*$_{it}$			
	(1)	(2)	(3)	(4)
postCWB$_t$**precip*$_i$	-0.0010***			
	(0.00033)			
postCWB$_t$**drought*$_i$		0.00041***		
		(0.00013)		
postCWB$_t$**temp*$_i$			0.0066*	
			(0.0039)	
postCWB$_t$**port_dist*$_i$				0.000066*
				(0.000037)
summer_precip$_{t-1}$	-0.00084**	-0.00084*	-0.00054	-0.00055
	(0.00040)	(0.00042)	(0.00041)	(0.00040)
pre-season_precip$_t$	-0.0000068	-0.0000037	0.000065	0.000056
	(0.00014)	(0.00014)	(0.00015)	(0.00014)
summer_temp$_{t-1}$	0.012	0.013	0.012	0.011
	(0.0085)	(0.0087)	(0.0077)	(0.0076)
CAR fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
Observations	311	311	311	311
R-squared	0.37	0.37	0.33	0.33
Number of CARs	30	30	30	30

Notes: This table reports the results of estimating regression equation (2) using linear OLS. A constant is included, but not reported, in all specifications. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1