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Mexican Agriculture and Policy under NAFTA

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Abstract. On the eve of the North American Free Trade Agreement (NAFTA), models predicted the transformation of Mexican agriculture, with imports precipitating the decline of domestic supply of staples, particularly corn, while fruit-and-vegetable exports drove sectoral growth. Trade flows have met expectations, but Mexican agriculture has not: both staple and specialty crops expanded during NAFTA's first decade, while their gross value declined; just as unexpectedly, their value has risen sharply since 2005. The Ministry of Agriculture (SAGARPA) has been credited with the apparent success of this export-led strategy, upholding the results-based management (RBM) of sectoral policy abetted by the National Council for the Evaluation of Social Development Policy (CONEVAL). This study offers a critical assessment of Mexican agricultural policy and its management in light of the sector's performance during the last 25 years. We report trends in the volume and value of agricultural output, land use, yields and prices. Using simple accounting methods, we show that price decreases accounted entirely for the sector's decline between 1993 and 2005. Since then, 67.0% of staples' gross value growth has be linked to rising prices, 27.4% to yield gains, and 5.6% to land-use change. For fruits and vegetables, these figures are 27.3, 50.0 and 22.7%. However, there is little evidence linking agricultural performance and policy. Only staple yields fall within policy's purview; yet yields of irrigated staples other than corn have stagnated this century. Additional evidence calls into question the success of RBM, including the dearth of diagnoses and impact evaluations supporting it. Their absence has not prevented constant reforms that systematically violate the integrity of the policy cycle. Official acknowledgement of drivers of growth will reveal the risks to Mexican agriculture, including its vulnerability to price fluctuations and reliance on select crops for growth. Academic engagement is a prerequisite for RBM's success.

Keywords: Results based management, SAGARPA, CONEVAL, corn, Mexico

Highlights:

- Having declined 31% between 1993 and 2005, Mexican agricultural gross value increased 68% (US$4.9 billion) by 2016.
- Of total growth, 54.4% was linked to prices, 33.4% to yields, and 12.2% to land-use change, but no evidence yet links growth to policy.
- Other evidence points to serious flaws in the results-based management (RBM) of Mexican agricultural policy.

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1. Introduction

A quarter century since the signing of the North American Free Trade Agreement (NAFTA), its implications for trade, production and welfare are still debated, not least those surrounding the Mexican agricultural sector (Weisbrot et al., 2014; Caliendo & Parro, 2015). In the years leading to NAFTA, models suggested that under every conceivable scenario the liberalization of agricultural trade would vastly increase grain imports into Mexico, lower prices for corn and other staples, precipitating the decline of their domestic supply—by up to 19% for corn (Robinson et al., 1993). On the other hand, free trade would raise the price of fruits and vegetables and increase their output by up to 13%. Owners of irrigated land were expected to benefit, while rainfed landowners, subsistence farmers and landless workers would be adversely affected, leading to widespread rural out-migration (Robinson et al., 1993; Levy & van Wijnbergen, 1994). Assessments of actual winners and losers in Mexican agriculture since then have diverged widely due as much to changing conditions as to selective use of information (Ramirez, 2003; Audley et al., 2004; Lederman et al., 2005; Romalis, 2007; Prina, 2013; Weisbrot et al., 2014). A decade into NAFTA, reviewers disputed whether corn imports had forced countless Mexican farmers to migrate as forecasts had it (Hornbeck, 2004). Some concluded that, with corn tariffs yet to be fully eliminated, Mexican agriculture was already a net loser in NAFTA, as grain imports displaced subsistence production and trade deficits translated into job losses (Audley et al., 2004). A different view failed to find the "negative effects on poor subsistence farmers", concluding that rural outmigration reflected secular trends in employment while Mexican agriculture had in fact "performed remarkably well" under NAFTA (Lederman et al., 2005). All accounts struggled to explain the corn sector's unexpected response.

In fact, although the domestic supply of corn experienced surprisingly little variation between 1993 and 2000, its gross value contracted 45% during this period; irrigated corn production declined markedly, driving a 29% loss of value in the staples sector, while rainfed corn experienced a considerable bout of immiserizing growth propelled by the *Programa de Apoyos Directos al Campo* (*PROCAMPO*) program (Dyer et al., 2006, 2018). As to fruits and vegetables, accounts coincided in pointing out the reassuring growth of exports under NAFTA while failing to notice the subsector's declining gross value—i.e., -22% between 1993 and 1995. As with the entire agricultural sector, specialty crops did not recover their pre-NAFTA value until 2007. Since then, Mexican agriculture's gross value has risen sharply (with both staples and specialty crops contributing to growth), allowing the Mexican Ministry of Agriculture (*Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación*, *SAGARPA*) to vindicate its export-led development strategy. Yet it is difficult to distinguish NAFTA's role from that of other factors, particularly Mexican agricultural policy. It has been argued, for instance, that the sharp drop in domestic corn prices was not the result of NAFTA but ultimately of long-standing policy (Fiess & Lederman, 2004; Lederman et al., 2005). That is, although NAFTA allowed for tariff rate quotas to protect Mexican corn production until 2008, rather than enforcing this prerogative, the Mexican government unilaterally allowed large volumes of tariff-free corn imports from the United States (U.S.) in order to reduce food and feed prices. Unsurprisingly, domestic producer prices followed the U.S.-price decline through the end of the century. Yet the cointegration of Mexican and U.S. corn prices predates NAFTA by at least a decade and operated during Mexico's long-running price controls (Fiess &

Lederman, 2004).

In comparison with the attention given to NAFTA's impact on Mexican agriculture in the peer-reviewed literature (Yúnez-Naude et al., in press), the interest placed on agricultural policy has been relatively scant. However Mexican policy has not gone unnoticed by international organizations that have drawn significant lessons from it (Grupo Interagencial de Desarrollo, 2009; FAO, 2014). In brief, during the early 1990s, the agricultural sector underwent extensive reforms that liberalized both trade and policy, including land reform (Appendini, 2010), the gradual eradication of public intervention in agricultural input and produce markets (Yúnez Naude et al., 2004), and ultimately the replacement of distorting policies with "green" subsidies through programs once considered innovative, such as the Alliance for the Countryside (*Alianza para el Campo*) and *PROCAMPO* (FAO-SAGAR, 2000; OECD, 2006; World Bank, 2009). In collaboration with the United Nation´s Food and Agriculture Organization (FAO) during the late 1990s, the Mexican government implemented the results-based management (RBM) of agricultural policy through *Alianza* (FAO-SAGAR, 2000).[1] After nearly a decade, the government had institutionalized the RBM of its development policy with the creation of the National Council for the Evaluation of Social Development Policy (*Consejo Nacional de Evaluación de la Política de Desarrollo Social* or *CONEVAL*) and its eventual regulation (DOF, 2004, 2007a), while FAO withdrew gradually. To date, *CONEVAL* has spearheaded Mexican development policy's RBM for over twelve years (CONEVAL, 2016); *SAGARPA* has presided over more than a decade of agricultural growth, while FAO has diffused the lessons of the Mexican experience across the developing world (FAO, 2014).

This paper offers an overview of Mexican agricultural policy and assesses its goals in light of the sector's performance during the last 25 years. Section 2 provides a brief description of agricultural policy—its priorities and structure—leading to and under NAFTA.[2] Section 3 describes the sector's performance in terms of the volume and value of crop output, ascribing changes in these variables to three driving factors: area sown, yields and prices. This analysis deals with direct drivers of change rather than ultimate causes; that is, it does not address causal relationships between land-use change and yields, nor their relationship to prices—all of which are areas in urgent need of research. Section 4 summarizes the influence of two decades of RBM on the evolution of the main "productive" programs. The section extends RBM's critical attitude to the practice of RBM itself in order to derive lessons from this experience.

2. Agricultural policy planning and programs

In addition to the Mexican government´s annual programming and budgeting exercise, every incoming administration develops plans and programs that establish policy priorities for the next six years. The National Development Plan (*Plan Nacional de Desarrollo* or *PND*) sets goals and regulates programming and budgeting across the entire federal administration; sectoral programs provide more specific objectives for each of several administrative branches (*ramos*), including the *Ramo* 8—i.e., Agriculture, Livestock, Rural Development, Fisheries and Food.[3] These goals and objectives reflect the evolving priorities of five federal administrations under NAFTA (Dyer et al., 2018). The Salinas administration's (1988-1994) priorities were to "modernize" Mexican agriculture, reduce the state's intervention, and liberalize trade and policy (DOF, 1991). In order to ease such transition, it created Support and Services to Agricultural Marketing—*Apoyos y Servicios a* *la Comercialización Agropecuaria* (*ASERCA*)—a federal agency that would help create (presumably private) agricultural trading companies; the agency itself was explicitly banned from participating in markets directly. *ASERCA* was meant to fill a widening gap left by the gradual dismantling of the agricultural state trading company, the *Compañía Nacional de Subsistencias Populares* (*CONASUPO*), which until then distributed subsidies through commodity purchases at controlled prices (*precios de garantía*) (Yúnez-Naude, 2003). *ASERCA* was also charged with running two "temporary support programs" for ailing farmers. The first was Market Support (*Apoyos a la Comercialización*), introduced in 1990 to "make fluid" the sale of market surpluses of staple crops without *CONASUPO*'s intervention. The second, created in 1993, was *PROCAMPO*, which pledged unconditional, lump-sum cash transfers for up to 15 years to owners of land historically sown with either of nine designated staples—corn, beans, wheat, rice, sorghum, soybeans, cotton, safflower and barley—ostensibly to compensate farmers adversely affected by U.S. farmers' competition under NAFTA. Both programs expended over half of the agricultural budget to keep the staples sector afloat.

In 1995, the Zedillo administration (1994-2000) prioritized the recovery of the sector´s "competitiveness and profitability" through its "productive reconversion" to fruits and vegetables, crops considered most profitable in the North American market (DOF, 1997). The Ministry of Agriculture (*Secretaría de Agricultura, Ganadería y Desarrollo Rural* or *SAGAR*) introduced *Alianza* in order to promote the transfer of technology, productive investment, producer organization and capacity development (FAO-SAGAR, 2000). The program's "modernizing" design—federalized, decentralized and participatory—was meant to grant considerable autonomy to state and municipal governments, professedly giving the rural population a say in regional and local development policy (Labastida & Zedillo, 1996; SAGARPA-FAO, 2008). *Alianza*'s funding grew 250% in real terms during its first eight years, benefiting from a burgeoning agricultural budget under the Fox administration (2000-2006). Reaching the status of *Apoyos a la Comercialización* and *PROCAMPO*, *Alianza* remained the sector's flagship "productive" program for over a decade. By 2004, these three programs disbursed 65% of the *Ramo* 8's resources.

Efforts to consolidate agricultural policy under NAFTA ended with the Fox administration. Since 2007, the *Ramo* 8 has been reformed continuously in a professed quest for administrative efficiency.[4] Ditching its own recommendation to maintain *Alianza* in operation (SAGARPA-FAO, 2008), the Calderón administration (2006-2012) replaced it, in 2008, with the new Productive Assets Acquisition Program (*Programa para la Adquisición de Activos Productivos* or *PAAP*). Its sole justification was to "rationalize and improve the efficiency of agricultural programs" (DOF, 2007b). Three years later it replaced the *PAAP* with the new Capital and Infrastructure Investment Support Program (*Programa de Apoyo a la Inversión en Equipamiento e Infraestructura* or *PAIEI*), citing again the need to improve the public sector's efficiency (DOF, 2010). In 2014, the incoming Peña Nieto administration (2012-2018) declared its priority "to make the agricultural sector a pillar of economic development again" (DOF, 2013a). It announced the sector's newest structural reform, dubbed *La Reforma del Campo*, and replaced the *PAIEI* with the Agricultural Promotion Program (*Programa de Fomento a la Agricultura* or *PFA*) in order "to use public resources more efficiently" (DOF, 2013b).

This continuous turnover of plans, programs and subprograms, and their goals and objectives defies systematization and makes evaluation of sectoral policy under NAFTA a daunting task. Paradoxically, the only constants in the *Ramo* 8´s programmatic structure during the last thirty years have been “temporary” programs—i.e., *Apoyos a al Comercialización* and *PROCAMPO*. Careful analysis of sectoral objectives, nevertheless, reveals a long-term development strategy pursuing Mexican agriculture’s “modernization” under ostensibly limited government intervention (Dyer et al., 2018). The shared sectoral objectives nominally guiding policy during the last thirty years are: i) safeguarding the income and general wellbeing of agricultural producers and the Mexican rural population more generally; ii) promoting domestic agricultural production and productivity; and iii) achieving Mexico’s food security and sovereignty. Only the second has been a formal objective of *SAGARPA*’s main “productive” programs, *Alianza*, *PAAP*, *PAIEI* and *PFA*. Accordingly, agricultural production and its drivers are the focus of the next section.

3. Agricultural land use, yields and output

This section reports trends in the volume and value of agricultural output, land use, yields and prices using data from the Mexican government’s Agrofood and Fisheries Information Service (*Servicio de Información Agroalimentaria y Pesquera*, *SIAP*).[5] Trends are characterized using Bai and Perron’s (2003) structural break tests and ordinary least squares regression on the individual segments thus defined. Unless otherwise stated, regressions assume a linear function of time, i.e., $y = \gamma_0 + \gamma_t \cdot t + \varepsilon$. Given the constrained length of the segmented series, power tests are used to determine the probability (β) of incurring type II errors in OLS estimation (Cohen, 1992). Locally weighted smoothing (LOESS) is used to complement the previous analyses (Cleveland & Devlin, 1988).

Changes in the value and volume of output are decomposed into their constituent factors based on the following accounting convention. Assuming that the combined effect of changes in any two factors on their product can be attributed equally to both factors, annual changes in value can be ascribed separately to either price or output, while changes in output can be ascribed to either yields or land use.[6] Each factor's contribution to cumulative changes in value and volume over time is calculated using an analogous procedure.[7] Since all contributions to a crop's value are expressed in real monetary terms, results can be added across crops to calculate each factor's contribution to changes in the value of the entire agricultural sector as well as the staples and fruits-and-vegetables subsectors. Since the period of analysis can be partitioned arbitrarily to highlight the evolution of each factor's contribution, factor decompositions are used here to calculate the cumulative contribution of changes in area, yields and prices to output and value over two roughly equal time spans: 1993-2005 and 2005-2016—the first corresponding with the decline of the agricultural sector's value, the second with its recovery.

Land use. In the five years preceding NAFTA (i.e., 1989-1993), agricultural land use oscillated close to 19.4 million hectares (ha). It then expanded 15% during NAFTA´s first four years, reaching 22.1 million ha in 1997, but has remained relatively constant since then, with 21.9 million ha cultivated in 2016.[8] Its brief expansion was mostly the result of land-use changes in rainfed areas, where cropland rose from 14.0 million ha in 1993 to 17.1 million in 1999.[9] Although irrigated cropland also increased by over 385 thousand ha in 1994—up to 5.6 million ha—it then contracted to 4.8 million ha by 2000.[10] Since then, land under irrigation has expanded by 1.2 million ha, while rainfed cropland contracted by 1.1 million ha.

Staple crops accounted for an overwhelming share of both rainfed and irrigated land brought into cultivation between 1994 and 1997. This expansion coincided with the introduction of *PROCAMPO*, which entitled farmers growing major staples to a steady flow of cash transfers. In effect, the addition by 1997 of 2.4 million ha to staple production in rainfed areas reversed the annual loss of 197.6 thousand ha (p<0.01) of cultivated land registered between 1984 and 1993.[11] Yet *PROCAMPO* had no lasting effect on irrigated staples, which contracted at the rate of 26.6 thousand ha/year during the 20th century's last two decades (p<0.01), 22% between 1994 and 2001.[12] Irrigated fruits and vegetables, as opposed, expanded at the rate of 13.8 thousand ha/year (p<0.01) during the latter period, while rainfed fruits and vegetables expanded by around 13.0 thousand ha/year (p<0.01).[13]

As mentioned, agricultural land-use has followed strikingly different trends during the 21st century. There has been a sustained contraction of rainfed cropland, from 17.1 million in 1999 to 15.9 million ha in 2016, largely offset by the simultaneous expansion of irrigated agriculture from 4.9 to 6.0 million ha. Irrigated staples have expanded at the rate of 58.5 ha/year (p<0.01) since 1998, irrigated fruits and vegetables at an increasing rate after 2008, i.e., 28.7 ha/year (p<0.01). At the same time, rainfed fruits and vegetables have expanded at a slightly decreasing rate since 1980, while rainfed land in staples is down 16.2% since 1999, its rate of decline having slowed to -45.3 thousand ha/year (p<0.01) after 2005.

Overall, the share of cropland devoted to fruits and vegetables has increased slowly but continuously since 1980, from 7.1% to 10.7% in 2016, while the share sown with staples decreased from 85.9 to 71.1% (see Appendix 1).[14] Although these trends have occurred in both irrigated and rainfed areas, irrigated land in staples has rebounded (by 24.5% between its minimum extent in 2000 and 2016), while rainfed staples contract (by 16% since its maximum extent in 1999).

Crop yields. Structural break tests for the main staples (i.e., grains, oilseeds, legumes and forages) under irrigation reveal constantly changing trends in yields during the last 35 years (Table 1A). The test for corn grain points to three distinct phases: yields increased at a constant rate of 0.2 ton/ha per year ($p<0.01$) between 1989 and 2010, but no proper trend can be discerned either prior to 1989 ($p=0.41$, probability of type II error $\beta=0.99$) or after 2010 ($p=0.17$, $\beta=0.97$). In 2011, corn yields fell an exceptional 40% due to frost, with total losses affecting >468 thousand ha in the northern state of Sinaloa.[15] Intriguingly, yields did not recover fully until 2014.

Table 1. Annual rates of growth of per-area yields for main staple crops in Mexico[1]

	A. Irrigated				B. Rainfed			
	Period[2]	γ	P	β	Period[2]	γ	p	β
Barley	1980-2011	0.09	<0.01	0.00	1980-2016	0.02	<0.01	0.66
	2011-2016	0.03	0.93	0.99				
Beans	1980-1992	0.002	0.65	0.99	1980-2016	0.004	<0.01	0.58
	1992-2006	0.01	<0.10	0.91				
	2006-2011	-0.08	0.12	0.97				
	2011-2016	0.05	0.27	0.99				
Corn grain	1980-1989	0.02	0.41	0.99	1980-2016	0.16	<0.01	0.00
	1989-2010	0.20	<0.01	0.00				
	2010-2016	0.34	0.17	0.97				
Corn feed	1980-1990	0.30	0.12	0.95	1980-2016	-0.14	<0.01	0.82
	1990-1996	1.20	0.23	0.98				
	1996-2016	-0.08	0.92	0.99				
Rice	1980-2004	0.103	<0.01	0.00	1980-1990	0.007	0.87	0.99
	2004-2016	0.008	0.75	0.99	1990-2011	-0.003	0.75	0.99
					2011-2016	0.09	0.42	0.99
Sorghum	1980-2002	0.09	<0.01	0.00	1980-2016	0.007	0.19	0.96
	2002-2016	-0.02	0.26	0.97				
Soybeans	1980-2016	-0.006	0.20	0.96	1980-2016	0.01	<0.01	0.81
Sugarcane	1980-2016	0.48	<0.01	0.01	1980-1987	2.50	<0.01	0.38
					1887-2016	-0.17	<0.01	0.67
Wheat	1980-2016	0.04	<0.01	0.00	1980-2010	0.02	<0.01	0.00
					2010-2016	0.07	0.45	0.99

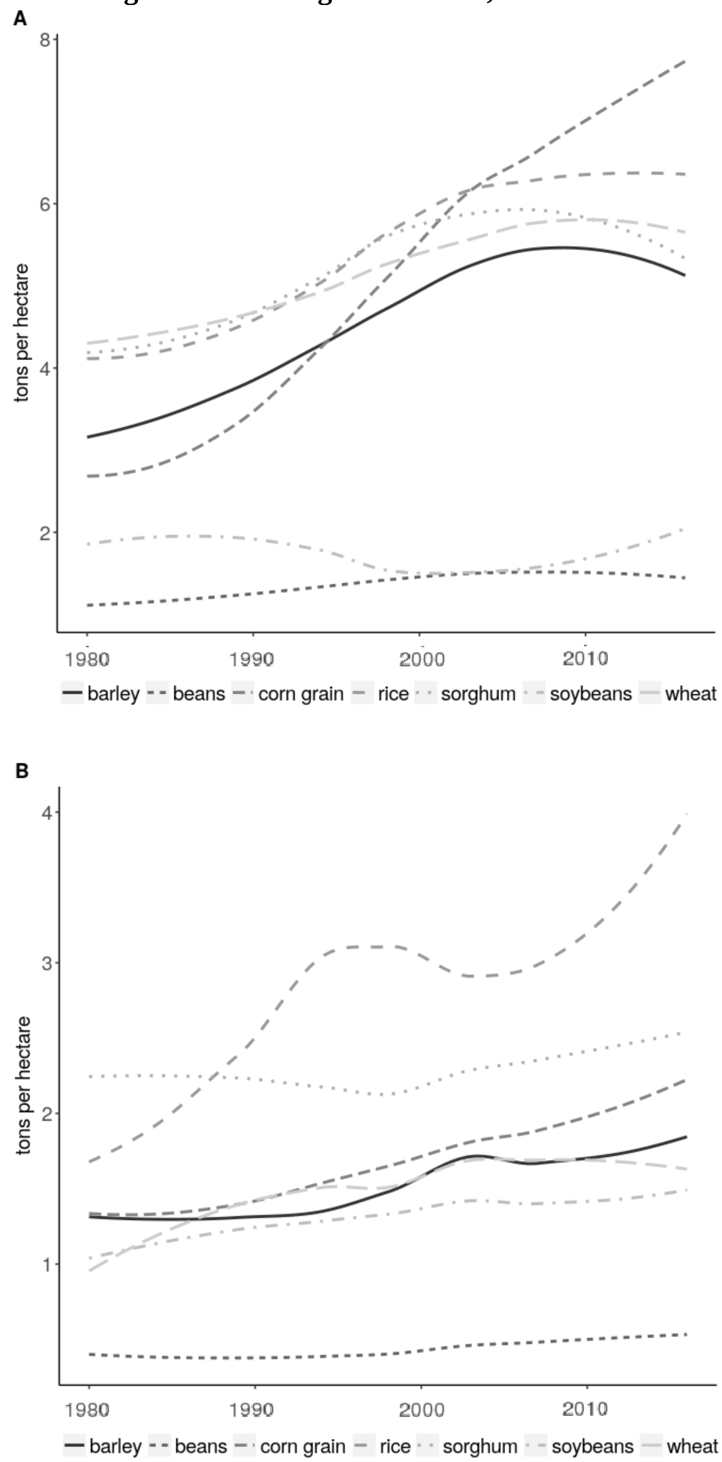
1. Tons per hectare per year
2. Periods identified using Bai and Perron's (2003) structural break tests (see Methods)

Structural break tests for irrigated sorghum, rice and barley show breakpoints in 2002, 2004 and 2011, respectively. Yields for these three crops increased at constant rates of 0.1 ton/ha ($p<0.01$, all crops) prior to those dates. Afterwards, no changes in yield are discernible for sorghum ($p=0.26$, $\beta=0.97$), rice ($p=0.75$, $\beta=0.99$) or barley ($p=0.93$, $\beta=0.99$); yet sorghum and barley yields have been particularly irregular, dropping 25 and 59% in 2015 and 2013, respectively. There is no significant evidence of structural breaks in yields for either wheat, sugar cane or soybeans. Yields for the first two increased 0.04 ($p<0.01$) and 0.48 ton/ha ($p<0.01$) per year, respectively, throughout the period, while evidence surrounding soy is inconclusive ($p=0.20$, $\beta=0.96$). Finally, highly variable yields for beans can be separated into four phases; except from 1992 to 2006, when yields increased 0.01 ton/ha per year ($p<0.10$), no proper trends are discernible ($\beta\geq0.97$).[16]

On the other hand, locally weighted smoothing (LOESS) suggests a surprising regularity in the behavior of yields of the main staples under irrigation. With the exception of corn grain, yields stagnated after the turn of the century, with similar patterns evident for sorghum, wheat, sugar cane, beans, barley and rice: their yields rose increasingly during the eighties, with inflection points around the mid-nineties, and reaching maxima during the 21st century´s first decade (Fig. 1A). While rice yields show no change over the past decade, the other five crops would have seen decreasing yields since then. As for soybeans, yields appear relatively stable prior to 1990, decreasing between 1990 and 2000, and slowly increasing since 2005.

Analyses suggest that yields for rainfed corn grain, barley, beans and soybeans followed single trends, albeit with relatively large variation; their yields increased at annual rates of 0.16 ($p<0.01$, $R^2=0.70$), 0.02 ($p<0.01$, $R^2=0.18$), 0.004 ($p<0.01$, $R^2=0.21$) and 0.01 ($p<0.05$,

Fig. 1 Yields of main irrigated (A) and rainfed (B) grains, oilseeds, legumes and forages in Mexico, 1980-2016

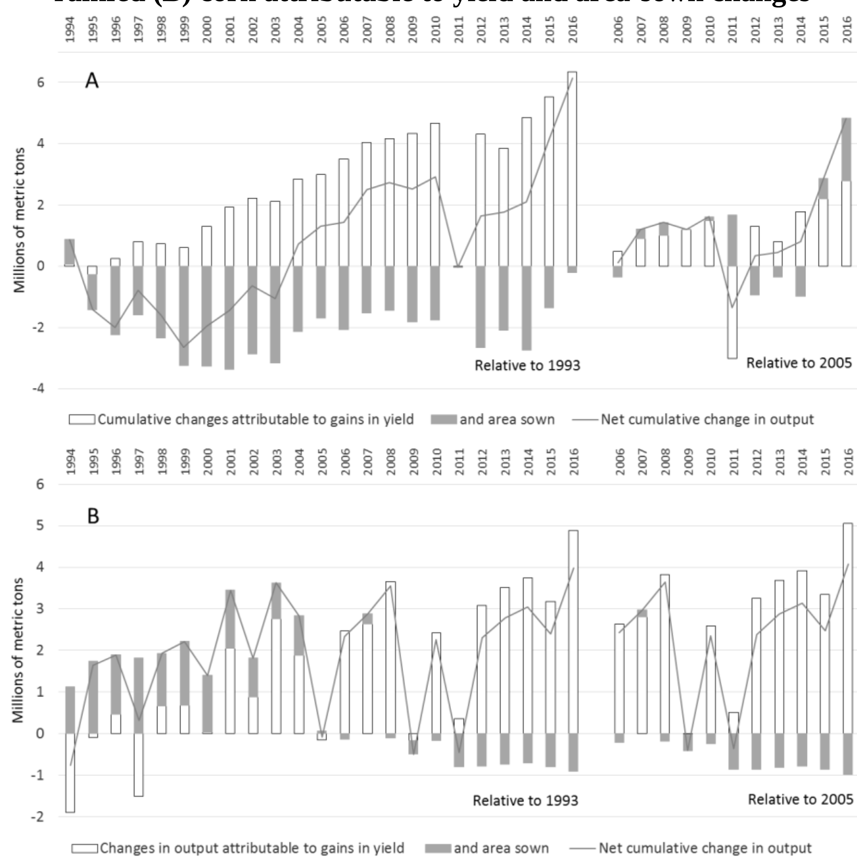


R^2=0.13) ton/ha, respectively (Table 1B).[17] LOESS curves suggest, nevertheless, that yields stagnated during the 1980s for corn, before 2000 for barley and beans, and after 2000 for soybeans (Fig. 1B). As to sugar cane and wheat, tests show single breakpoints: sugar cane yields increased at an annual rate of 2.50 ton/ha ($p<0.01$) before 1987, decreasing 0.17 ton/ha per year ($p<0.01$) thereafter; both patterns are confirmed by the LOESS curve. Wheat yields increased at a rate of 0.02 ton/ha ($p<0.01$) before 2010 but followed no discernible trend afterwards ($p=0.45$, $\beta=0.99$); the LOESS curve suggests they stagnated after 2000. Yields for sorghum saw no breaks, or in fact any discernible changes throughout the period ($p=0.19$, $\beta=0.96$); yet the LOESS curve suggests increasing yields after 2000. Finally, rice yields experienced breaks in 1990 and 2011, but no change in yields is discernible at any stage (p=0.87, 0.75 and 0.42, $\beta=0.99$).[18] The LOESS curve suggests increases before 1990 and after 2010.

Crop output and value. The supply of all major crops has varied markedly over the past thirty years, reflecting shifts in yields and area sown in both irrigated and rainfed areas.[19] At the onset of NAFTA, irrigated and rainfed production of corn were respectively at high and low points, but the situation changed rapidly. A sharp contraction in area drove irrigated output down 41% by 1999 (Fig. 2A). It has recuperated since then, growing 173% by 2016, 48% in the last four years. Yield gains have been largely responsible for this recovery; but area expansion has played an increasing role in recent years, accounting for an average 20% of growth since 2005 but 74% since 2012 (Appendix 1). In rainfed areas, as opposed, corn expanded 19% between 1993 and 1997, but gains were then reversed within a decade; by 2016, the crop's area was 7% lower than in 1993. In the long run, yield gains have offset this contraction, raising rainfed output 38% above its pre-NAFTA level.

Output has nevertheless fluctuated by as much as 29% per year, due largely to weather-related yield losses (Fig. 2B). In sum, extensification accounted for 72% of rainfed growth between 1993 and 2005; since then, all growth has derived from yield gains, while a diminishing area sown has implied a 24% loss in output. Overall, irrigated areas supplied 47% of the domestic corn supply in 1994, 51% in 2009, and 49% in 2016; but rainfed areas have contributed an average 60% of the total under NAFTA.

Fig. 2. Cumulative changes in output of irrigated (A) and rainfed (B) corn attributable to yield and area-sown changes



Source: Authors' estimates based on SIAP data (see Methods and data)

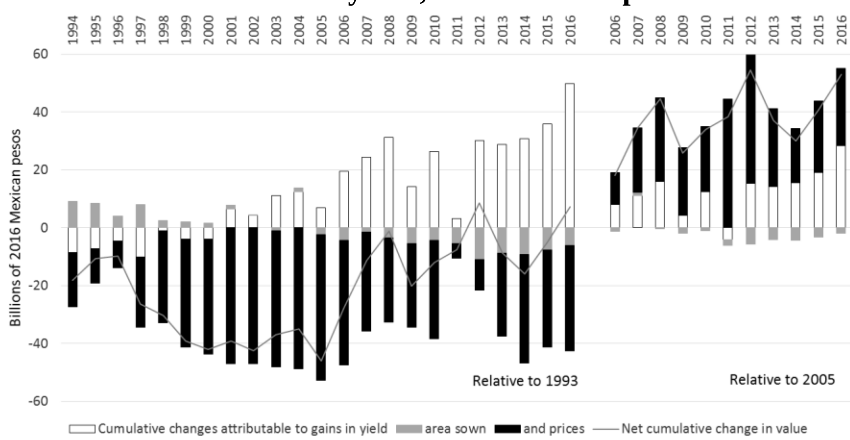
In comparison, sugar cane and sorghum—i.e., the second and third most valuable staples—have shown relatively regular trends (Fig. A1, A2 in Appendix 1). Driven mostly by area expansion, their output under irrigation has grown almost continuously since 1993, while yield gains played a relatively minor role. In rainfed areas, extensification has been partially offset by decreasing yields for sugar cane, while sorghum output has stagnated as the area sown returns to its pre-NAFTA extension.

Whether judged in terms of area, volume or value, the main specialty crops in rainfed areas have been five perennials—i.e., oranges, bananas, mangoes, avocados and lemons. Among these, the output of avocados and lemons has grown most—i.e., 287 and 280%, respectively, between 1993 and 2016 (Fig. A3 to A4).[20] Extensification has been increasingly important for both crops: its share of output growth before and after 2005 was 58 and 81% for avocados, 61 and 70% for lemons.

In irrigated areas, chili peppers, and to some extent tomatoes, have been the most important specialty crops in terms of land use, output and value. Between 1993 and 2016, their output increased 155 and 104%, respectively, due mostly to gains in yields (Fig. A8, A9); avocado's increased 95%, mostly during the last decade, with yield gains accounting for all growth prior to 2005, and area expansion for all growth since then (Fig. A3). Increasingly valuable albeit still minor specialty crops have been asparagus, blackberries and strawberries, whose area expansion has accelerated, contributing 23, 57 and 100% of output growth since 2005.

Despite the growth of corn output, the crop's value declined almost continuously during NAFTA's first decade, 50% by 2005. All net losses were therefore due to falling prices (Fig. 3). Between 1993 and 2005, the expansion of the area sown in corn accounted for 96% of value growth in average, yield gains for the remaining 4%. Since 2005, the crop´s value has increased 114%; prices accounted for 68% of average annual value gains during this period, yields for the remaining 32%, while its area contracted. Differences between rainfed and irrigated production are noteworthy. In rainfed areas, higher prices and yields have contributed 59 and 41% of annual value gains since 2005, respectively, while the crop's area contracted. Under irrigation, their contribution has been 80 and 15.5%, with area expansion accounting for the remaining 4.5%.

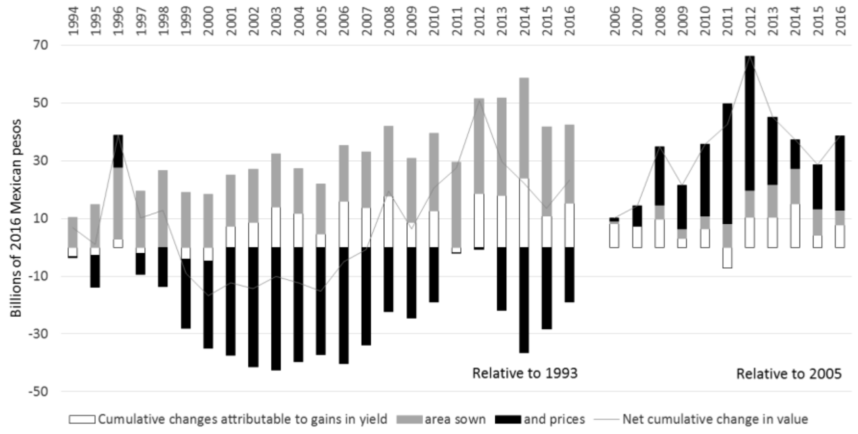
Fig. 3. Cumulative changes in the total value of corn attributable to yields, area sown and prices



Source: Authors' estimates based on SIAP data (see Methods and data)

Similarly, the rest of the staples sector suffered a 15% loss of value between 1993 and 2005 due entirely to falling prices (Fig. 4). In this case, area expansion and yield gains accounted for 87 and 13% of gross value growth. Since 2005, prices, yields and area have accounted for 62, 20 and 18% of growth. In irrigated areas, nevertheless, these crops did not lose value as a whole (relative to 1993) until 1999, and then not for long or more than 21%.[21] Since 2005, 64% of value growth has depended on favorable prices, 26% on area expansion, and only 10% on yield gains. In rainfed areas, by comparison, prices, area and yields have contributed 60, 13 and 27% of growth during this period.

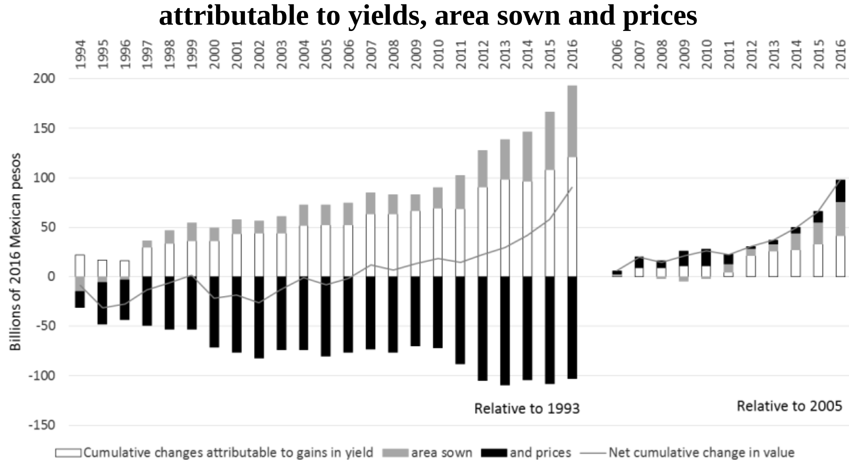
Fig. 4. Cumulative changes in the total value of the staples sector (excluding corn) attributable to yields, area sown and prices



Source: Authors' estimates based on SIAP data (see Methods and data)

As to fruits and vegetables, the sector's 22% loss of value between 1993 and 1995 also was due almost entirely to lower prices (Fig. 5). By 2005, yield and area gains had contributed much to its recovery yet did not entirely offset the effect of recurrent price decreases; the sector's value still remained 5.5% below its pre-NAFTA level. Since 2005, its value has risen 79%, with yields, prices and area contributing 50, 27 and 23% of growth in average. However, rainfed production has depended mostly on prices for growth, i.e.,

Fig. 5. Cumulative changes in the total value of fruits and vegetables attributable to yields, area sown and prices



Source: Authors' estimates based on SIAP data (see Methods and data)

51% since 2005, with yields contributing only 27%. While irrigated production surpassed its pre-NAFTA value conclusively in 2006, rainfed production did not do so until 2013.

A short diagnosis. Two significant patterns in agricultural land use stand out during the last decades: a) a tendency for rainfed and irrigated land use to counterbalance, keeping total cropland relatively constant; and b) the simultaneous expansion of fruits and vegetables and contraction of staples. There is little evidence, nevertheless, that either NAFTA or the "productive reconversion" policy of the Zedillo administration accelerated the conversion of land into fruits and vegetables. That is, even if exports to the U.S. have driven the sector's growth (Yúnez-Naude et al., in press), land-use trends did not change noticeably with NAFTA—i.e., conversion of irrigated land into specialty crops proceeded at a relatively constant rate, while that of rainfed land has slowed steadily since the early 1980s. In fact, other policies might have inadvertently prevented an accelerated conversion. For instance, the largest adjustment in agricultural land use since the late 1980s was the expansion of rainfed staples under *PROCAMPO*—a program conceived as decoupled from production and meant to have no influence on land use (Dyer, 2010). While rainfed land in staples has contracted constantly after the start of the program, this process presumably got under way independently of NAFTA, in the mid-1980s.[22] Similarly, the extensification of staples in irrigated areas has likely been the result—and undeclared purpose—of the Market Support Program (Echánove, 2013).

Independently of policy goals, land-use change has had important implications for agricultural growth. For instance, the surge of rainfed corn after 1994, as mentioned, was largely achieved through area expansion. While corn production has gradually moved out of rainfed areas since then, it has expanded once again under irrigation, driving output growth since 2012 (Fig. 2). Sustained growth of sugar cane and sorghum output under NAFTA also has been achieved largely through extensification (Fig. A1, A2). Area expansion has similarly enabled the rapid growth of major rainfed fruits and vegetables (e.g., avocado and lemons, Fig. A3, A4) as well as upstart specialty crops under irrigation (e.g., asparagus, blackberries and strawberries). In sum, area expansion helped maintain the agricultural sector afloat between 1993 and 2005, contributing 47% of gross value growth in average, and 89% for staples. Although there has been no discernable expansion of agricultural land use this century, land conversion (particularly to fruits and vegetables) has also contributed 12% of agricultural value growth since 2005.

A pervasive goal of agricultural policy has been to raise crop productivity and output via yield improvements, particularly for staples, which would presumably help achieve Mexico's food security and sovereignty. Between 1993 and 2005, yield gains contributed an average 53% of all gross value growth in agriculture—but mostly in fruits and vegetables. In the staples sector, yield gains represented only 11% of value growth during this period, well below area expansion. As the area sown in staples began declining this century, yields became the main source of output growth; but due to their weakening performance (Fig. 1), these gains fell far behind prices in the generation of value (Fig. A10).

Overall, prices have been the fundamental driver of Mexican agriculture's gross value under NAFTA. As mentioned, between 1993 and 2005, price decreases offset yield gains and area expansion entirely, turning output growth into net value losses for both staple and specialty crops. After 2005, as opposed, rising prices have been responsible for 54% of total value growth, 67% in the staples sector and 27% in fruits and vegetables. Yet it is noteworthy how few crops were responsible for value growth. Among fruits and vegetables, six crops—i.e., chili peppers, tomatoes, avocados, blackberries, strawberries and asparagus—accounted for 60% of all growth between 2011 and 2016. In the staples sector, the value of corn increased Mex$14.7 billion during the same period, while other crops suffered a combined loss of Mex$4.1 billion.

4. Results-based management of agricultural policy

A basic principle of results-based management (RBM) is that a sector's diagnosis drives the policy cycle. This section offers a diagnosis of RBM itself. FAO's collaboration with *SAGARPA* over the span of a decade resulted in the development of methodological tools for RBM (FAO, 2014). The history of Mexican agricultural policy's RBM reflects the steep learning curve of this collaboration as well as the course it has taken after its institutionalization over a decade ago. The section describes both phases. RBM is now conceived as consisting of four crucial stages coinciding with a program's life cycle: i) the sector's diagnosis, which identifies the policy problem and the affected population; ii) the program's design, which addresses the problem and includes objectives, baseline and performance indicators; iii) the program's implementation and monitoring; and iv) the eventual evaluation of its impacts (FAO, 2014). Progress across these stages has been noticeably uneven.

Alianza para el Campo: 1996-2007. Few other agricultural programs in Mexico have been assessed more thoroughly and systematically than *Alianza*.[23] In addition to the long-running, collaborative effort mentioned above (SAGARPA-FAO, 2008; Grupo

Interagencial de Desarrollo, 2009), various international organizations and research groups have conducted independent assessments of *Alianza* (OECD, 2006; World Bank, 2009; Fox & Haight, 2010; Palmer-Rubin 2010). Still, it is difficult to say whether this program achieved its goals or what its benefits were. *Alianza* was not based on a deliberate diagnosis of the sector´s situation but on a covenant with entrepreneurial and organized producers affected by the new market rules. The program had no formal design—its general goals were not clearly stated—but relied on its annual Rules of Operation (*Reglas de Operación* or *ROP*) to define constantly changing objectives (SAGARPA-FAO, 2008). Lacking a clear design or formal statement of purpose, *Alianza*'s operation shifted continuously across and within the political cycle, preventing long-term planning (OECD 2006, Palmer-Rubin 2010). Its notoriously complex institutional structure hindered efforts to address actual demand for public support, to audit the program's operation, and ultimately to evaluate its results (SAGARPA-FAO, 2008).

A crucial aspect of its decentralization, the distribution of federal funds to the states, was completely discretionary, based on one-on-one negotiations, until the Fox administration introduced an objective formula to apportion these funds. However, this formula was largely arbitrary—i.e., based on past allocations rather than actual demand—and likely resulted in an inefficient distribution of support (Caballero, 2006; SAGARPA-FAO, 2008; World Bank, 2009). Within the guidelines set by the program's *ROP*, decentralization also granted each state the right to define the types of support available and the eligible population.[24] However, state governments never defined the program's potential or objective populations (SAGARPA-FAO, 2008). Lacking an assessment of these populations' situation or perceptions, there was never an attempt to estimate the need for

Alianza's support or to address it (SAGARPA-FAO, 2008). This situation was aggravated by the apportionment of federal funds to the states based on historical precedent, which favored states with the largest agricultural sectors rather than those with highest potential for growth or most disadvantaged (World Bank, 2009; Palmer-Rubin 2010). Overall, *Alianza*'s distribution of support was always highly regressive under the unproven assumption that this was most efficient (Caballero, 2006; OECD, 2006; CEDRSSA, 2007; World Bank, 2009; Palmer-Rubin 2010).

In its final years, *Alianza*'s goal became to promote the autonomous participation of mainly low-income producers in agribusiness. Yet no changes were introduced to improve the program's operation or pursue this new goal (SAGARPA-FAO, 2008), which oddly, given the program's importance, had no obvious connection to any of the sectoral program's 118 objectives (see below). Overall, there is little evidence of *Alianza*'s material benefits. *SAGARPA* generated few useful indicators of the program's performance during its lifespan (SAGARPA-FAO, 2008); it never established the total number of participants or collected the necessary information or feedback from them. Constant changes in the participant pool and the multiplicity of schemes implemented worsened this situation (SAGARPA-FAO, 2008). However, it is still possible to ascertain that the program did not solve producers' liquidity constraints, since resources were disbursed only after expenses were made and documented, which excluded producers that lacked liquidity or access to credit (Palmer-Rubin, 2010). Finally, *SAGARPA* did not perform cost-effectiveness assessments or even regular accounting of the program's operation costs. Although *Alianza*'s *ROP* contemplated the establishment of "social auditors", these never operated. The lack of transparency led to clientelism, patronage and misallocation of funds (Caballero, 2006;

SAGARPA-FAO 2007; Palmer-Rubin 2010). At best, *Alianza* had a modest impact on participants' income that hardly justified its expenditure (SAGARPA-FAO, 2008). *Alianza*'s evaluation itself accomplished few of the goals it set out to pursue (FAO-SAGAR 2000; SAGARPA-FAO, 2008).[25]

In 2007, *SAGARPA* and FAO published a set of recommendations for an improved program under the new federal administration, describing *Alianza* at once as one of the most coherent agricultural programs in Mexico, the fruit of a long institutional improvement process, and an indispensable platform for other sectoral programs (SAGARPA-FAO, 2007). Among other recommendations were the following: *Alianza* should i) promote investment in public rather than private goods and services, particularly in technological innovation, food safety and environmental quality; ii) operate under a single chain of command and a long-term policy perspective; iii) address its objective population "dilemma", focusing on smallholders (i.e., rural development) while keeping support for peasant agriculture under a single program; and iv) be subject to a renewed and more ambitious evaluation schedule, including rigorous impact assessments.

***The past decade*.** *Alianza* ceased operating in 2007, but purportedly it contributed to the development of the results-based management (RBM) of Mexican development policy (CEDRSSA, 2007; FAO, 2014). Since that year, federal law requires the continuous monitoring and evaluation of every program subject to *ROP*; new programs must be accompanied by a formal diagnosis justifying their creation, referencing the policy problem they address and its links to sectoral objectives (DOF, 2007a). In order to assess progress towards specific objectives, federal agencies must generate and update a set of performance indicators. At least five types of evaluations are considered in the legislation—i.e., consistency and results; indicators; processes; specific, and impact evaluation—but only the latter focuses on the actual effects of policy (DOF, 2007a). Ultimate responsibility and utility of evaluations is not clearly established. Most significantly, while normativity suggests that federal agencies are required to act on all recommendations (DOF, 2007a), this mandate has been subject to interpretation.[26] In practice, recommendations have not been binding.

In 2008, the *PAAP* program became operational as part of the *Ramo* 8's latest restructuring. Its objective—i.e., "to contribute to the ownership of strategic capital goods among the rural population"—was a response to a tenacious policy problem: "the low level of rural economic units' capitalization" (DOF, 2007b; SAGARPA-FAO-ILPES, 2008). Successive evaluations noted the persistent absence of a diagnosis, yet none disputed *SAGARPA*'s rationale for abandoning existing agricultural policy as embodied in *Alianza* and its objectives (SAGARPA-FAO-ILPES, 2008; CONEVAL-SAGARPA, no date A, B). In support of *SAGARPA*'s justification, evaluations unanimously adduced the problem's high relevance, scope and precedence; they also found its objective well founded on the sectoral program's general objectives and the *PND*'s national goals.

When the sector's diagnosis was finally published, in 2012, a new reform had already replaced the *PAAP* with the *PAIEI*, whose *ROP* simply paraphrased its predecessor's objective, i.e., "to raise economic units' levels of capitalization" (DOF 2010). The diagnosis determined nevertheless that this goal's precedence was in fact low and did not justify the *PAIEI*'s status as a program but a component's rank at most (SAGARPA-FAO, 2012). Subsequent evaluations concurred, finding this time that such objective was not in line with either the sectoral program's or the *PND*'s higher order goals, which obviously remained unchanged (CONEVAL-SAGARPA, no date C, D; SAGARPA-FAO, 2013). It was recommended that the entire *Ramo* 8 be restructured once again and the *PAIEI* redesigned, refashioning current components into "8 or 10 new programs" (CONEVAL-SAGARPA, no date C, D).[27] Clearly, this neglected that Mexican agricultural programs' nominal objectives rarely reflect actual policy, its goals, budgets or instruments (CEDRSSA, 2007; SAGARPA-FAO, 2007; SAGARPA-FAO, 2013).[28] Thus, rather than dividing the *PAIEI* into multiple programs, it would be much more expedient to rephrase its objective, as the new administration did, in 2014, after replacing the *PAIEI* with the new *PFA*. That is, although the *PFA* comprised the same set of instruments as its predecessors (SAGARPA, no date), it professed a higher objective—i.e., "to increase rural agricultural economic units' production and productivity"— earning praise from the *PFA*'s evaluators (CONEVAL-SAGARPA, no date F). The sector's capitalization—i.e., *PAAP* and *PAIEI*'s shared objective—was thus demoted to a component's rank, which had in fact been its place within *Alianza*'s structure.[29] To this extent, the three consecutive reforms endorsed by *CONEVAL* between 2008 and 2014 managed to abolish *Alianza*'s structure—while preserving its objective population dilemma and other deficiencies—only to reinstate this structure seven years later. In terms of RBM efforts, these reforms have had a significant cost, since new programs are not expected to follow previous programs' recommendations—and in fact have not.

Indeed, the gap between official rhetoric and policy is most evident in connection to the targeting and distribution of subsidies, i.e., *Alianza*'s dilemma (CEDRSSA, 2007). Raising the sector's low productivity presumably requires targeting those farmers lacking the means to invest in capital assets, which entails sorting program applicants accordingly

(SAGARPA-FAO, 2008; SAGARPA-FAO, 2014; SAGARPA, no date). Yet, under *Alianza*, state governments failed to identify and target this demographic, eschewing an explicit responsibility to identify the program's potential, objective and beneficiary populations (FAO-SAGARPA, 2008). The program's repeated evaluation was ultimately unable to: i) locate records of program beneficiaries' precise identity, ii) determine whether or not they could afford capital assets, or iii) assess what the actual demand for support was (SAGARPA-FAO, 2008). In sum, *Alianza* never entertained a strategy to transit from an open, on-demand-subsidies scheme to one that actively targeted and extended coverage to those "in need". Shunning disadvantaged states and farmers, the distribution of funds remained based on historical allocations (Caballero, 2006).

In effect, no estimate of a program's potential population or its targeting can be pursued without a measure of Mexican producers' ability to acquire assets or otherwise raise their productivity (SAGARPA-FAO-ILPES, 2008). In turn, the absence of targeting will preclude any assessment of such program's coverage and thus the establishment of a long-term coverage strategy. Significantly, neither the *PAAP* nor the *PAIEI* offered any improvement over *Alianza* on these issues; yet successive evaluations were remarkably inconsistent in calling out their shortfalls. In this regard, the *PAAP*'s "design" evaluation observed that its potential and objective populations were either undefined or entirely inadequate, as the program's eligibility was not characterized in terms of the policy problem it was meant to address, i.e., lack of access to assets (SAGARPA-FAO-ILPES, 2008). The *ROP* 2008 had defined strata based on producers' income, wages and ownership of either land, cattle or a business enterprise; but rather than limiting eligibility to a particular stratum, *SAGARPA* maintained it wide open (DOF, 2007b). Since demand for support is typically kept in check by the limited diffusion of program information, the status quo could be relied on to favor better-off producers (Orrantía Bustos, 2006).

Yet subsequent evaluations largely overlooked these deficiencies, describing the *PAAP*'s objective population as clearly defined (CONEVAL-SAGARPA, no date A, B). They also lauded the program's decentralization, ignoring *Alianza*'s discouraging precedent on this regard. With no other justification, their recommendations focused on the need for states to define their potential and objective populations through "custom-made stratifications" of applicants based on the sector's pending diagnosis (SAGARPA-FAO-ILPES, 2008; CONEVAL-SAGARPA, no date A, B). *SAGARPA* obliged, abrogating its own stratification immediately while granting state governments the right to establish bespoke eligibility rules (DOF, 2008). Unsurprisingly, the eventual publication (in the diagnosis) of a stratification of producers along with the assessment of a potential population—i.e., the number of farmers lacking the means to meet their own capital requirements—did not lead to improved targeting (CONEVAL-SAGARPA no date C, D). Actually, the new *PAIEI* represented a regression in terms of eligibility, as the *ROP* 2011 defined different objective populations for each component, none of which targeted disadvantaged farmers (DOF, 2010). This made even the most perfunctory assessment of the program's coverage all but impossible (CONEVAL-SAGARPA, no date E). The awaited state-level stratifications failed to materialize, yet the *PAIEI*'s "consistency and results" evaluation overlooked their absence (CONEVAL-SAGARPA, no date C). Interpreting the diagnosis's stratification as the norm, both *SAGARPA* and *CONEVAL* neglected that it was in effect inoperative, since eligibility rules continued to be a prerogative of state governments, now at liberty to consider asset ownership or not (DOF, 2010). Naturally, subsidies continued to be granted on-demand (CONEVAL-SAGARPA, no date D; SAGARPA-FAO, 2013).

Criticism eventually caught up with the *PAIEI*'s failure to address *Alianza*'s dilemma (CONEVAL-SAGARPA, no date D), setting the stage for a new reform. In 2015, during the *PFA*'s second year, the program was subject to a belated design evaluation that nevertheless found ample justification for *PFA*'s creation in its new objective, earning it the highest marks (CONEVAL-SAGARPA, no date F). *CONEVAL* also concluded that the *PFA*'s diagnosis (SAGARPA, no date) identified the policy problem correctly, described its causes, effects and their evolution sufficiently, recognized its potential population and provided a coherent, medium-term strategy to cover the latter (CONEVAL-SAGARPA, no date, F). Yet, at the same time, it was evident that the *PFA* would not address *Alianza*'s dilemma. Its diagnosis had defined the program's potential population in terms of those "rural economic units" facing "the problem" at hand, but it also defined the *PFA*'s target population in increasingly regressive terms, to include not only all agricultural producers and organizations but also trading and manufacturing firms linked to the primary sector (SAGARPA, no date; DOF, 2013b, 2014). *CONEVAL*'s recommendations focused on compelling *SAGARPA* to resort to the existing stratification (i.e., SAGARPA-FAO, 2014) and standardize all definitions of potential and objective populations in order to effectively target rural economic units facing "the problem" (CONEVAL-SAGARPA, no date F, G); but no substantial changes in targeting have been made by 2018. Remarkably, this sums up RBM efforts in agricultural policy— to date, no program operated by *SAGARPA* has been the object of an impact evaluation.

A broken loop. RBM is best described as a feedback loop where the lessons learned during a stage in a program's life cycle inform actions in subsequent stages and cycles (FAO, 2014). The success or failure of the results-based strategy thus depends as much on the mechanisms enabling this feedback as on the cycle's integrity. In principle, the cycle starts with the sector's diagnosis, which provides both a motive for reform and the basis for its design; in a second stage, objectives and objective populations are defined, instruments designed and performance indicators selected to lay the groundwork for the program's implementation; this third stage entails not only the program's operation but also monitoring and data gathering for the eventual evaluation of its impacts, which occurs in a fourth stage that in closing validates the cycle (FAO, 2014). In practice, the four program cycles of Mexican agricultural policy since 1995 have started in the third stage—i.e., the implementation of a new program—yet ended short of the fourth—impact evaluation—while stages one and two are performed after the fact and often perfunctorily. That political expediency and administrative convenience have driven each cycle, rather than the diagnosis of a prevailing problem, both contravenes RBM principles and flouts federal regulation requiring that this diagnosis precede the program's funding (DOF, 2007a). Since regulations do not condition funding to the vetting of a program's design, *CONEVAL*'s efforts have largely been spent untangling successive programs' objectives and objective populations ex post. Some of the consequences of compromising the cycle's integrity are documented in previous subsections. The adequacy of mechanisms to ensure feedback across stages is addressed here.

Implementing a program without due consideration has myriad implications. Beyond the obvious, the Mexican experience shows that the flaws and weaknesses in a program's early stages preclude progress later in its life cycle. For instance, lack of proper definitions and measures of their objective populations has made monitoring of agricultural programs' coverage a futile effort. Similarly, that monitoring of these programs' performance has been widely off the mark can be traced to the poor scrutiny of their objectives (see below). A different implication has been the absence of a discussion on the instruments intended to achieve particular objectives (CEDRSSA, 2007). Clearly, the need to vet a program's design thoroughly before funding it is one of the lessons of this experience. While stricter regulation and enforcement might help preserve the cycle's integrity, there is ample evidence that RBM's institutionalization has not created proper feedback mechanisms, nor more generally, conditions favorable to the deliberate analysis of policy.

In order to fulfill its mandate, *CONEVAL* has standardized its evaluation methodology, subcontracting its application across sectors and programs indistinctly to third parties. This combination has had serious drawbacks. In rewarding prior experience in the application of those methods, *CONEVAL*'s selection of prospective evaluators is entirely biased against new entrants. Rather than encouraging an open discussion and critical assessment of RBM, this practice has stifled debate and enabled rent seeking. Its methodology has been impugned by both assessors and assessed as inadequate, rigid and formulaic (SAGARPA, 2010; CONEVAL-SAGARPA, no date C).[30] Its emphasis on ticking boxes creates incentives for both *SAGARPA* and program evaluators to focus on scoring points on formal details rather than addressing substantive issues. Overall, these practices have substituted commercial enterprise for academic endeavor, turning evaluators into stakeholders, ultimately compromising both evaluations and the results-based strategy as a whole. The outcome has been a notoriously superficial feedback process lacking integration, consistency, institutional memory or a long-term perspective. Two examples suffice to substantiate these claims: a) the handling of the objective population dilemma; and b) the monitoring of agricultural policy's performance.

It has been assumed for over a decade that the absence of targeting is a technical problem that the sector's diagnosis would solve by stratifying producers (SAGARPA-FAO-ILPES, 2008). All prescriptions have been based on this prognosis and specifically call for targeting the bottom three strata (in the diagnosis) as the way to solve the sector's most compelling problem (CONEVAL-SAGARPA, no date A, C, D, F, G). Indeed, the diagnosis identified those strata as undercapitalized (SAGARPA-FAO, 2012); but the prescription is fundamentally unsound, not least of all because "the problem" has changed—it no longer requires targeting undercapitalized producers but those whose productivity is lagging.[31] *CONEVAL*'s oversight has also ignored that, at best, such strata represent the status quo a decade ago at the time of *Alianza*. Moreover, it disregards the absurdity of sorting applicants according to abstract categories predetermined through two-step cluster analysis (SAGARPA-FAO, 2012, p. 513). In fact, it is hard to say what these strata represent, as they fail to sort producers according to asset ownership, productivity or income—e.g., 42% of farms employing drip irrigation are labelled as having capitalization problems, while 14% of those without such problems (i.e., categorized in "entrepreneurial" strata) suffer food poverty (SAGARPA-FAO, 2012). In general, critical inspection of this and later diagnoses has been completely lacking[32], while *Alianza*'s dilemma eludes a solution.

After two decades of results-based agricultural policy in Mexico, the Agricultural Promotion Program or *PFA* presumably represents its state of the art. Its performance is monitored through two indicators—i.e., farm-labor productivity and agricultural gross value—sanctioned by *PFA*'s design evaluation (CONEVAL-SAGARPA, no date F).

Progress is measured against predetermined goals. According to *CONEVAL*'s latest reports, tangible progress was registered in 2015 and 2016, when *PFA*'s annual productivity goal was met by 106% and 99%, respectively, its value goal by 87 and 109% (CONEVAL-SAGARPA, no date G, H). Curiously, none of these indicators corresponds with the program's actual objective—i.e., increasing agricultural production and productivity—which finds justification in a "strategic" sectoral objective—"to increase grain and oil seed output"—and two diagnoses that explicitly identify staples' low yields as the problem with crop productivity (SAGARPA, no date, 2015a). In fact, since the contribution of production to the staples sector's value remained stagnant between 2014 and 2016, 97% of growth can be attributed to price increases (Fig. A10); excluding corn, changes in yields during this period represented a net loss of value (Fig. 4). In this context, rather than progress, *PFA*'s performance indicators reveal declining on-farm employment and rising food prices (ENOE, 2018; INPC, 2018). Since rural job creation and affordable food are among *SAGARPA*'s sectoral objectives (DOF, 2013a), this illustrates the lack of consistency and integration of RBM's current practice.

5. Conclusions

Any discussion of the road ahead must start from a deliberate analysis of Mexican agriculture and policy. This study touches upon a discussion largely absent from the literature. Linking the sector's performance to either trade or sectoral policy remains a challenge (Yúnez-Naude et al., in press). Unlike its counterpart in the U.S., *SAGARPA* maintains no models that can explain or forecast present and future trends in this performance (SAGARPA-AFPC-FAPRI, 2009; SAGARPA, 2011). *SAGARPA* does not consider formal scenarios of its policies' impacts. Yet, with *CONEVAL*'s endorsement, it has not hesitated to credit these policies with recent growth (SAGARPA, 2015b, 2017; Presidencia de la República, 2018). Such statements are blatantly antithetical to the spirit of RBM (UNDP, 2009; FAO, 2014). Significantly, the main factor driving agriculture's performance—i.e., crop prices—is the one over which Mexican policy forswears control. International markets (or the peso's revaluation against the U.S. dollar) could bring domestic crop prices down again, along with agriculture's gross value, wiping out most of the growth now attributed to policy. Vulnerability to price fluctuations is exacerbated by the sector's reliance on a handful of crops for growth. The greatest risks are for irrigated farms in staples, whose gross income has benefited most from price increases. Although rainfed farms have also benefited, larger gains have come from yields. In the fruits-and-vegetables sector, it has been rainfed farms whose growth has depended most on prices, while irrigated farms have relied most on yields.

Another factor outside the scope of policy has been land-use change. The significant contribution of agricultural extensification to sectoral growth contrasts with the absence of an explicit land-use policy in Mexico (Dyer, 2010)—or a discussion of its environmental implications (Abler & Pick, 1993). The absence of a discernable trend in agricultural land use during the last two decades does not reflect a static agricultural frontier but the constant abandonment of rainfed land in the context of persistent deforestation, or its conversion to pasture (López et al., 2006; García-Barrios et al., 2009; van Vliet et al., 2012).

It is productivity then that has commanded the attention of federal policy. And yet it remains beyond our reach to ascertain this policy's impact on crop yields—in this respect, there have been no advances since the time of *Alianza*. In itself, such assertion calls into question the success of Mexican agricultural policy's RBM; yet there are additional reasons to suspect it. Yield gains have contributed 33% of agricultural gross-value growth during the sector's recovery, 50% for fruits and vegetables. However, *SAGARPA*'s main productive program was not implemented on the presumption of low yields for specialty crops, but for staples, particularly in rainfed areas. A "strategic" objective to increase the domestic supply of grain and oil seed has warranted considerable additional resources for irrigated staples, through the Market Support Program, long after its rationale has vanished (Echánove, 2013).[33] Irrigation also benefits from Mex$24 billion per year in subsidies to electrical rates through the Agricultural Energy Special Program (*Programa Especial de Energías para el Campo*) (Robles Berlanga, 2017). And yet, during the 21st century, most major irrigated staples have seen their yields stagnate (Table 1A, Fig. 1A); whatever gains were achieved contributed less than 13% of their value growth, 10% excluding corn (Fig. 4, A10).[34] Remarkably, rainfed yields for corn and other staples have risen despite the relative absence of public support (Table 1B, Fig. 1B). Perhaps if farmers preferably abandon marginal land or reincorporate it into cultivation as conditions change, yield gains and losses have moved along land-use change (i.e., the contraction of staples in rainfed areas and their expansion under irrigation). Surprisingly many questions remain unaddressed in a sector with Mex$514 billion (US$27.5 billion) in annual sales.

Interest in NAFTA's repercussions unfortunately has not translated into greater scrutiny of Mexican agriculture and policy in the literature or the press. RBM has failed to fill this gap. In many respects, its institutionalization has meant a step backward. It has failed to recognize that before the technical problems in agricultural policy there are those of conflict of interest—i.e., *SAGARPA*'s commitments to both entrepreneurial and subsistence agriculture, to producers as well as consumers and farm labor (Dyer et al., 2018). Standard procedure at *CONEVAL* has brought additional interests into policy evaluation, foreshadowing patterns that were once thought outdated (CEDRSSA, 2007; Schwentesius Rindermann et al., 2007). For over a decade, RBM has focused on a discussion of policy objectives that has literally ran in circles, oblivious to the absence of a proper diagnosis. An inordinate institutional effort has been devoted to the proclamation of sectoral and national development goals, and the strategies said to pursue those goals, ignoring that regulation depends first and foremost on *ROP* that habitually break the spirit of the law (Echeverri Perico et al., 2013). Closed and ignorant of policy's true impact on agriculture, this discussion has naturally run aground striving to legitimize constant administrative reform in the face of a persistent status quo. Actual policy suggests that its underlying goals and strategy have been absent from official rhetoric; namely, to depend for growth and a favorable trade balance on entrepreneurial agriculture's fruit-and-vegetable exports, while using public subsidies to underpin its profitability, particularly in staples (Echánove, 2013). As trade surpluses finally materialized in recent years, an apparently long cherished economic goal turned into political liability. Negotiations to reform NAFTA may explain why deficits have a central role in trade policy. However, there is no evidence that this unofficial strategy guiding Mexican agricultural policy for decades, can achieve either trade surpluses or rural development.

It is hard to justify a new reform that is not based on the widest public discussion and considerable engagement of academia. Many challenges lie ahead and many decades of costly but failed efforts to bring development to rural Mexico. While none of *Alianza*'s deficiencies mentioned above have been rectified, and no recommendations for its improvement fulfilled, these issues predate *Alianza* by several decades. In 1973, the Echeverria administration (1970-1976) launched the Integrated Rural Development Project (*PIDER*) to raise the productivity of farmers living in poverty, redressing the abiding imbalance of public support hitherto favoring irrigated agriculture and entrepreneurial producers (World Bank, 1975). Proving "instrumental in securing considerable institutional change" and reporting advances in extension services, local participation, decentralization, inter-agency coordination and project evaluation, *PIDER* was soon institutionalized (World Bank, 1977). In 1984, a sudden administrative reform consolidated *PIDER* into a larger federal program. Two years later, the project's completion report described *PIDER* as over-ambitious, lacking local participation, extension services and inter-agency coordination, and unable to remedy its shortcomings (World Bank, 1986). The causes included lack of long-term planning and adequate monitoring and evaluation, all of which were associated with administrative reform in the agricultural sector (World Bank, 1990). Clearly, Mexico's democratization over the last decades has not translated into policies more favorable to either rural development or the majority of smallholders. The persistence of economic and policy outcomes favoring an elite despite constant institutional change seems to adhere to Acemoglu and Robinson's (2008) model of captured democracy.

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[1] The results-based strategy uses constant monitoring and evaluation of policy to inform its planning and implementation, delivering greater effectiveness and accountability in government (UNDP, 2009; FAO, 2014).
[2] This analysis is limited to agriculture (i.e., the cultivation of crop fields), excluding livestock, fisheries and aquaculture. A full-fledged assessment of three decades of agricultural policy is, nevertheless, beyond our present goals. No attempt is made to cover here all individual agricultural programs, their general goals and specific objectives, budgets, instruments, target populations, eligibility, coverage, operational processes and their known impacts.
[3] Sectoral objectives are pursued through individual programs (i.e., schemes) that commonly nest multiple "components" (subprograms). Subsidy programs are regulated by annual "rules of operation" that provide their own general and specific objectives as well as "objective" (i.e., target) populations and their rules of

eligibility. Since 2007, their objectives must be formally based on the sectoral program's objectives, which in turn must be supported on national goals (DOF, 2007a). Less formal but equally ubiquitous are so-called strategies—including "transversal" (i.e., administration-wide) strategies—that presumably establish how specific objectives contribute to general ones and ultimately to national goals. All administrative branches, their individual programs and their components are known collectively as the programmatic structure of the Federal Administration. The annual federal budget (*Presupuesto de Egresos de la Federación* or *PEF*) earmarks resources for each element in this structure.

[4] The *Ramo* 8's restructuring has typically consisted of a haphazard, short-term rearrangement of programs and subprograms that may change their goals but keep their names, or vice versa (Robles Berlanga, 2017). For instance, since 2011, *SAGARPA*'s main food security program, the *Proyecto Estratégico de Seguridad Alimentaria* (*PESA*), has been an "integral" part of five different programs; in 2014, the erstwhile *PROCAMPO* became part of the *Programa de Fomento a la Agricultura* (*PFA*) under the name *PROAGRO*; in 2017, *SAGARPA* merged the surviving components of its two rural development programs—i.e., the *Programa de Productividad Rural* and the *Programa de Apoyos a los Pequeños Productores*—maintaining the latter's name but none of these programs' goals.

[5] Instead of using *SIAP*'s tabulated price data, the analysis uses prices implicit in volume and value data (i.e., price = value/volume), which differ between irrigated and rainfed areas; see https://www.gob.mx/siap.

[6] Given that crop output (O) is the product of area (A) sown and average per-area yield (Y)—i.e., $O_t = Y_t \cdot A_t$— annual changes in output are given by $\Delta O_{t+1} = Y_t \cdot \Delta A_{t+1} + A_t \cdot \Delta Y_{t+1} + \Delta A_{t+1} \cdot \Delta Y_{t+1}$ for any two consecutive years, where $\Delta y_{t+1} = y_{t+1} - y_t$, for y = O, A and Y. Obviating all sub-indexes momentarily, the contribution of each of these individual factors to a crop's output can be approximated assuming that their combined effect, $\Delta A \cdot \Delta Y$, is due in equal parts to each, so that $\Delta O^A = (Y + \Delta Y/2) \cdot \Delta A$ and $\Delta O^Y = (A + \Delta A/2) \cdot \Delta Y$, where ΔO^A and ΔO^Y represent the change in output due to a change in area and yield, respectively, and thus $\Delta O = \Delta O^A + \Delta O^Y$. Similarly, given that the gross value (V) of output is the product of total output (O) and per-unit real price (P)—i.e., $V = P \cdot O$—the separate contributions of ΔO and ΔP to ΔV can be approximated by $\Delta V^O = (P + \Delta P/2) \cdot \Delta O$ and $\Delta V^P = (O + \Delta O/2) \cdot \Delta P$, where ΔV^O and ΔV^P represent changes in value associated with changes in output and price, respectively. Substituting terms, annual changes in value can be decomposed into the separate contributions of the three factors—i.e., area, yields and price—as follows: $\Delta V = (P + \Delta P/2) \cdot \Delta O^A + (P + \Delta P/2) \cdot \Delta O^Y + (O + \Delta O/2) \cdot \Delta P = \Delta V^A + \Delta V^Y + \Delta V^P$.

[7] The cumulative contribution of area sown and yields to changes in output over time, $\Delta O_t = O_t - O_0$ for $t \geq 1$, can be calculated for any given year, t, with respect to an arbitrary base year, 0, as follows: $\Delta O^A_t = (Y_0 + \Delta Y_t/2) \cdot \Delta A_t$ and $\Delta O^Y_t = (A_0 + \Delta A_t/2) \cdot \Delta Y_t$. Also, the cumulative contribution of area, yields and price to ΔV_t can be calculated as: $\Delta V_t = \Delta V^A_t + \Delta V^Y_t + \Delta V^P_t$, for any given year, t, with respect to an arbitrary base year, 0.

[8] OLS regressions of the three separate structural segments detected suggest a 614.9×10^3 ha/year (p-value that $\gamma_t = 0$ is <0.01) increase in cropland use between 1993 and 1997, but no discernible trends either before ($p=0.80$, $\beta=0.99$) or after ($p=0.11$, $\beta=0.93$) this period. LOESS suggests a slow expansion of cropland during the 21st century. All structural break tests are based on the Bayesian information criterion (BIC); all LOESS estimates are based on a span value of 0.75.

[9] Analyses suggest two breaks in land-use change in rainfed areas; between 1993 and 2005, change is best described as a quadratic function of time—$\gamma_t = 257 \times 10^3$ ha/year ($p<0.01$) and $\gamma_{t^2} = -5.5 \times 10^3$ ha/year ($p<0.01$)—with a maximum around 2000. Although no trends are discernible either before ($p=0.30$, $\beta=0.99$) or after ($p=0.44$, $\beta=0.99$) this period, LOESS suggests a slight contraction during the 21st century.

[10] A single break is evident for irrigated areas; land use decreased 24.5×10^3 ha/year ($p<0.05$) before 1999 and increased 78.3×10^3 ha/year ($p<0.01$) thereafter. It is often hard to reconcile *SIAP* data on irrigated land use with other official sources, such as the National Water Information System (*Sistema Nacional de Información del Agua* or *SINA*).

[11] Analysis reveals breaks for rainfed staples in 1993 and 2005: land use decreased by 198×10^3 ha/year ($p<0.01$) prior to 1993 and 45×10^3 ha/year ($p<0.01$) after 2005; between these dates, land use can be described by a quadratic function of time—$\gamma_t = 257 \times 10^3$ ha/year ($p<0.01$) and $\gamma_{t^2} = -5.5 \times 10^3$ ha/year ($p<0.01$)— decreasing after 1999.

[12] Structural analyses show that irrigated staples contracted prior to 1998 but expanded after this date.

[13] Tests show that the rate of expansion for irrigated fruits and vegetables increased after 2008 from 13.8 to 28.7×10^3 ha/year ($p<0.01$). Analogous tests suggest that the rate for rainfed fruits and vegetables decreased after 1985; yet variation is best explained by a single regression with a dummy variable to control for this

abnormal year, 1985: both linear—γ_t = 13.0x10^3 ha/year ($p<0.01$)—and quadratic regressions are highly significant—γ_t = 609.4x10^3 ha/year ($p<0.01$) and γ_{t^2} = -149.2x10^3 ha/year ($p<0.01$).

[14] The remaining 18.1% of land constitutes cultivated pastures and perennial crops such as coffee, agave and cocoa.

[15] http://infosiap.siap.gob.mx:8080/agricola_siap_gobmx/ResumenDelegacion.do (Consulted April 12, 2018.)

[16] A single regression that assumes no structural breaks suggests that bean yields increased at an annual rate of 0.01 ton/ha ($p<0.01$) throughout the entire period.

[17] Rates of change for yields of irrigated (0.20 ton/ha·year) and rainfed maize (0.16 ton/ha·year) differ significantly (t=11.1, d.f.=38, $p<0.01$).

[18] A single regression that assumes no structural breaks suggests that rice yields increased at an annual rate of 0.05 ton/ha throughout the entire period ($p<0.01$).

[19] This subsection summarizes a more detailed analysis presented in full in Appendix 1.

[20] Oranges, mangoes and bananas' output has experienced severe, periodic contractions due to sudden drops in yields (Fig. A5-A7). Between 1993 and 2016, the volume of the first two increased 45 and 29%, mostly before 2005, while bananas' decreased 9.5% (Appendix 1).

[21] In comparison, irrigated corn grain lost 62% of its pre-NAFTA value and took 19 years to recover.

[22] Its long-term decline has presumably been a response to the constant decrease of grain prices since the early 1980s, yet the recent rise in prices has managed only to slow this downward slide.

[23] See CEDRSSA (2007) and Schwentesius Rindermann et al. (2007) for a review of *PROCAMPO*'s experience.

[24] Official guidelines were notably confusing. According to SAGARPA-FAO (2008), it was state governments' prerogative to define their objective populations. However, the program's *ROP* declare that state governments should define program eligibility "considering at least the objective population" formally defined in the *ROP*. This was defined, quite narrowly, as all legally constituted rural producer organizations. Other phrasing in the *ROP* suggest nevertheless that this population includes all natural and legal persons individually or collectively involved in productive activities in rural areas.

[25] These goals included assessing the coverage, performance, efficacy and efficiency of *Alianza* programs in every state, as well as the degree to which states achieved their own goals while addressing the population's "needs" (FAO-SAGAR, 2000).

[26] *"OCTAVO.- La Secretaría, la Función Pública, y el Consejo en el ámbito de su competencia, evaluarán conjuntamente la congruencia entre los objetivos estratégicos de las dependencias y entidades y los fines de los programas federales. Dicha evaluación podrá realizarse anualmente y formará parte del proceso presupuestario. Las dependencias y entidades deberán considerar los resultados de dicha evaluación y atender las recomendaciones y medidas derivadas de la misma. La Función Pública supervisará que las recomendaciones hayan sido atendidas. […] DECIMO PRIMERO.- Las dependencias y entidades presentarán la matriz de indicadores de cada programa federal, en los términos que se establezcan en el calendario de actividades del proceso presupuestario. La Secretaría, la Función Pública, y el Consejo en el ámbito de su competencia, revisarán conjuntamente la matriz de indicadores y sus modificaciones conforme al mecanismo que se determine para dichos efectos en el marco del proceso presupuestario, emitiendo las recomendaciones que estimen pertinentes y, cuando proceda, la aprobación respectiva. […] DECIMO SEGUNDO.- Las dependencias y entidades deberán atender las recomendaciones a que se refiere el lineamiento anterior y realizar las modificaciones en la matriz de indicadores y en las reglas de operación de los programas federales sujetos a las mismas, en los términos de las disposiciones aplicables, así como difundir la matriz actualizada a través de su página de Internet dentro de los 10 días hábiles siguientes a su aprobación. […] VIGESIMO QUINTO.- Las dependencias y entidades deberán dar seguimiento a los aspectos susceptibles de mejora de los programas federales derivados de las evaluaciones realizadas, conforme al convenio de compromisos de mejoramiento de la gestión para resultados que celebren."* (DOF, 2007a).

[27] Few of *PAIEI*'s various components and subcomponents were actually related to farmer capitalization (CONEVAL-SAGARPA, no date D).

[28] "*En relación a los bienes privados, las cifras presentadas* […] *señalan que hay insuficiencias en materia de focalización de recursos, pues los montos asignados no se corresponden con las definiciones políticas y conceptuales que SAGARPA ha establecido para la gestión de Alianza para el Campo*" (SAGARPA-FAO, 2007). "*Por otro lado, la distribución de los recursos del Programa entre Componentes y conceptos de apoyo específicos no se lleva a cabo atendiendo los objetivos y metas establecidos en la MIR o en algún otro instrumento de planeación, sino que sigue una lógica inercial en la asignación de los montos de recursos*"

(SAGARPA-FAO, 2013).

[29] "To promote investment in the agricultural sector and its capitalization" was the objective of the Investment and Capitalization Promotion Subprogram (*Subprograma de Fomento a la Inversión y Capitalización*), part of *Alianza*'s own Agricultural Promotion Program (*Programa de Fomento Agricola*). That is, capitalizing the agricultural sector had in fact a component's rank under *Alianza* (DOF, 2003).

[30] "*La Evaluación Específicas de Desempeño del programa realizadas* [sic] *en 2008 presentó, en algunos casos, carencias metodológicas y conceptuales, lo que implicó un informe de evaluación débil y con poca utilidad para la mejora del programa. Estas mismas debilidades se continúan manifestando en la EED del Programa de Adquisición de Activos Productivos 2009-2010.* […] *Respecto a los resultados de la Evaluación Específica de Desempeño 2009-2010, realizada al Programa de Adquisición de Activos Productivos, estos son cuestionables, toda vez que el objetivo de este tipo de evaluación es el de valorar el desempeño de los programas federales, mediante criterios homogéneos.* […] *Las consideraciones generales que realiza el evaluador externo son someras y poco relevantes, en sí no hay un análisis concreto sobre el desempeño del programa*" (SAGARPA, 2010). "*La presente evaluación constituye únicamente una valoración sintética del desempeño del Programa, que atiende a un formato estandarizado establecido por el CONEVAL. De allí que si se quisiera profundizar más en el diseño, planeación del Programa y/o en su operación, habría que realizar evaluaciones más amplias y profundas de estos temas*" (CONEVAL-SAGARPA, no date, C). "*La evaluación no puede contemplarse como una actividad fabril, donde lo importante es la estandarización de métodos y prácticas para obtener los mejores resultados. Las prácticas de evaluación, que en muchos sentidos se acercan a una práctica de investigación científica, no pueden someterse a esta visión mecanicista. La necesidad de formación de cuadros profesionales locales que con su conocimiento profundo de los requerimientos regionales, impulsen la descentralización, se ve fuertemente disminuida, si la evaluación estatal, por su apego pasivo a un formato metodológico es excesivamente uniforme*" (CEDRSSA, 2007).

[31] Since smallholders (who are often undercapitalized) tend to over-employ labor, the overlap between the two potential populations is not clear-cut (Yúnez Naude et al., 2016).

[32] All three diagnoses performed since 2012 are based on data from the same *Linea Base SAGARPA* 2008 survey of program beneficiaries (SAGARPA-FAO, 2012; SAGARPA, no date and 2015a). Since the survey is clearly not representative of Mexican agricultural producers, strata as well as estimates of potential populations systematically neglect farms excluded from federal programs.

[33] "*La concentración de apoyos mencionada obedece a una histórica tendencia dentro de la política agrícola mexicana a beneficiar mayoritariamente a los productores "competitivos", es decir, a los grandes y medianos productores comerciales, los cuales se ubican fundamentalmente en el norte del país*" (Echánove, 2013).

[34] While corn yields have risen, most increases could be due to genetic gains embodied in germplasm, as it has happened in the U.S. corn sector (Smith & Kurtz, 2015).

Appendix 1.

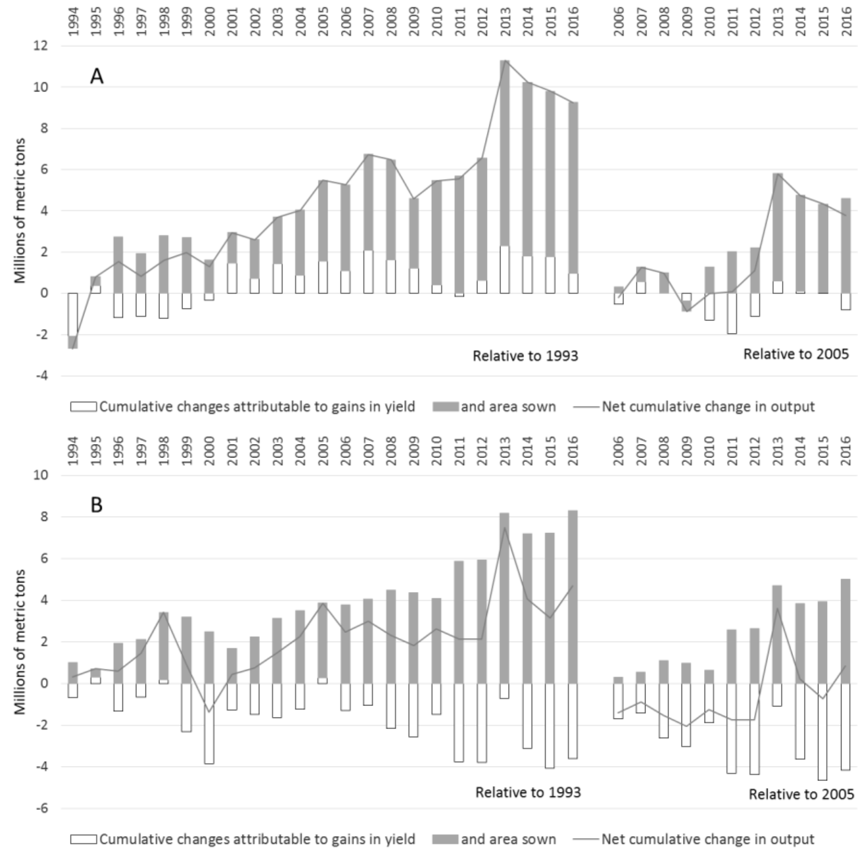
Land use. In terms of land use, since 1994, the main staple crops have been corn (covering an average 49.8% of staples' area), sorghum and beans (11.9% each), and wheat and sugar cane (4.5% each). In irrigated areas, corn and beans have been relatively less important (covering an average 33.8 and 6.2% of irrigated land in staples, respectively), while wheat and sugar cane have been more (14.3 and 7.4%). In rainfed areas, as opposed, wheat has occupied a distant 8th place (with 1.4% of the area), behind oats (4.5%), corn forage (2.4%) and barley (2.1%). In general, the area sown with staple crops for human consumption (i.e., corn grain, beans and wheat) has decreased during NAFTA, allowing sugarcane and forages (e.g., oats, corn forage, and alfalfa) to expand. An exceptional case has been irrigated corn grain, which occupied 43% of irrigated land in staples in 1994 and, after a pronounced lull, 39% in 2016. Fruits and vegetables with the widest land use have been oranges and lemons (covering an average 17.2 and 7.1% of total land in this subsector since 1994, respectively), mangoes (8.8%), chili peppers (7.6%), avocadoes (6.1%) and tomatoes (5.7%). In irrigated areas, chili peppers (covering 11.7% of irrigated land), tomatoes and oranges (8.6% each) have been most important. In rainfed areas, on the other hand, oranges, mangoes and bananas have occupied an average 27.1, 12.1 and 5.5% of the land, respectively. While still important, other fruits and vegetables mentioned above have been slightly less prominent in rainfed areas than in general. Overall, the share of land in lemons and avocado has increased considerably. Except for chili peppers and mangoes, which have not followed a discernable trend, other major fruits and vegetables have seen their shares decrease, including oranges, tomatoes and bananas, as well as apples, grapes and potatoes. On the other hand, relatively minor specialty crops that have spread since 1994 include strawberries (14% growth), asparagus (54.8%) and blackberries (1815%).

Crop output. The supply of all major crops has varied markedly over the past thirty years, reflecting shifts in yields and area sown in both irrigated and rainfed areas.[xxxv] One of the most idiosyncratic cases is that of corn grain, the main staple in Mexico. Irrigated corn was experiencing a high point at the onset of NAFTA, its area having expanded 97% between 1989 and 1994 due partly to favorable relative prices. A simultaneous 60% increase in yields had contributed to a 215% rise in output since 1989, contrasting markedly with the 3% decline during the previous five years. Incentives changed rapidly after 1994, with most of the previous area gains undone by 1999 and output falling 41% (Fig. 2A). Although yields improved during this time, they did not offset the resulting loss of output entirely until 2004, when production reached again its previous maximum. By 2004, a new area expansion was contributing more to rising output than yields, but these became again the main driver of growth as the expansion ceased. Output growth slowed considerably, yet by 2010 the volume of irrigated corn was 110% greater than in 1999. Irrigated land under corn increased drastically again in 2011, but frost resulted in extremely low yields and a 28% fall in output. In 2012, yields, area and output remained lower than in 2010 but then rose noticeably. Output has grown 48% since 2012, with a new area expansion accounting for 74% of growth in average. Overall, area has accounted for an average 20% of growth since 2005, while yield gains accounted for all net growth before then, with area changes then representing sizable losses (Fig. 2A).[xxxvi]

In contrast, the rainfed area under corn was at a low point in 1993. It increased for four years thereafter, 19% by 1997, but has decreased 22% since then. In fact, previous gains in area had been reversed entirely by 2005. Yet a persistent upward trend in yields has maintained output growth and raised it to its maximum in 2016, 38% above 1993 (Fig. 2B). While area expansion accounted for 72% of growth between 1993 and 2005, in average, yields have been responsible for all growth since 2005, with area contraction equivalent to a 24% loss of output. Driven mostly by weather-related fluctuations in yields, year-to-year variation has been as high as 29%. Overall, rainfed areas have supplied up to 69% of the annual corn output during NAFTA, 60% in average; yet irrigated areas contributed 47% of that output in 1994, 51% in 2009, and 49% in 2016.

Sugar cane and sorghum—i.e., the second and third most valuable staples—have followed very different trends (Fig. A1, A2). Irrigated sugar cane production grew increasingly between 1993 and 2013, 59% in total, driven mostly by area expansion. Area accounted (in average) for 88% of growth during those years; the exception was 2009, when output dropped 7.3% driven primarily by a contraction in area. Output has decreased gradually since 2013, 6.7% in total, with lower yields responsible for 62% of average losses (80% of total loses). Overall, fluctuating yields have generated mostly losses since 2005, while an expanding area has accounted for all net growth. Rainfed output has been more variable, with trends changing periodically due largely to fluctuating yields. A constantly expanding rainfed area has been entirely responsible for the 20% increase in output since 1993, while recurring yield decreases have represented up to a 19% output loss with respect to 1993. Similar patterns were observed before and after 2005. As to sorghum, the third most important staple, its output under irrigation increased 150% during NAFTA's first three years, largely through a 137% expansion in area. It then decreased and stagnated, but it saw a decade of sustained growth after 2004. In 2014, irrigated output was 284% greater than in 1993, with an expanding area contributing 79% of growth relative to 1993. Output

Fig A1. Cumulative changes in output of irrigated (A) and rainfed (B) sugar cane attributable to yield and area-sown changes

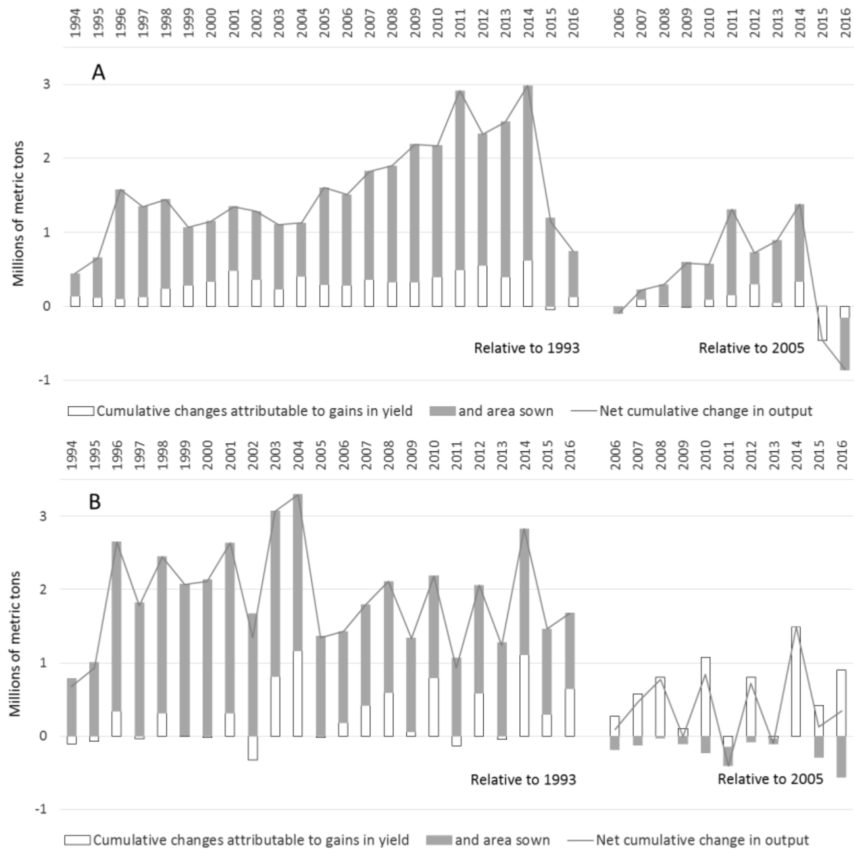


Source: Authors' estimates based on SIAP data (see Methods and data)

has decreased 55% since then, mostly through a significant reversal of that expansion; yield gains contributed an average 22% of growth before 2005 and 17% since then. Rainfed output also increased right after NAFTA due to an expansion in area, 173% by 1996 and 216% by 2004. It then declined and stagnated and has seen little further growth. In 2016, output was 34% lower than in 2004. Overall, area expansion contributed an average 90% of growth before 2005, while yield gains accounted for all net growth after that year.

In the fruits-and-vegetables sector, the same five perennials fruits—i.e., oranges, bananas, mangoes, avocados and lemons—represent the main rainfed crops whether judged in terms of area, volume or value. Yet when compared to avocados and lemons, which have grown

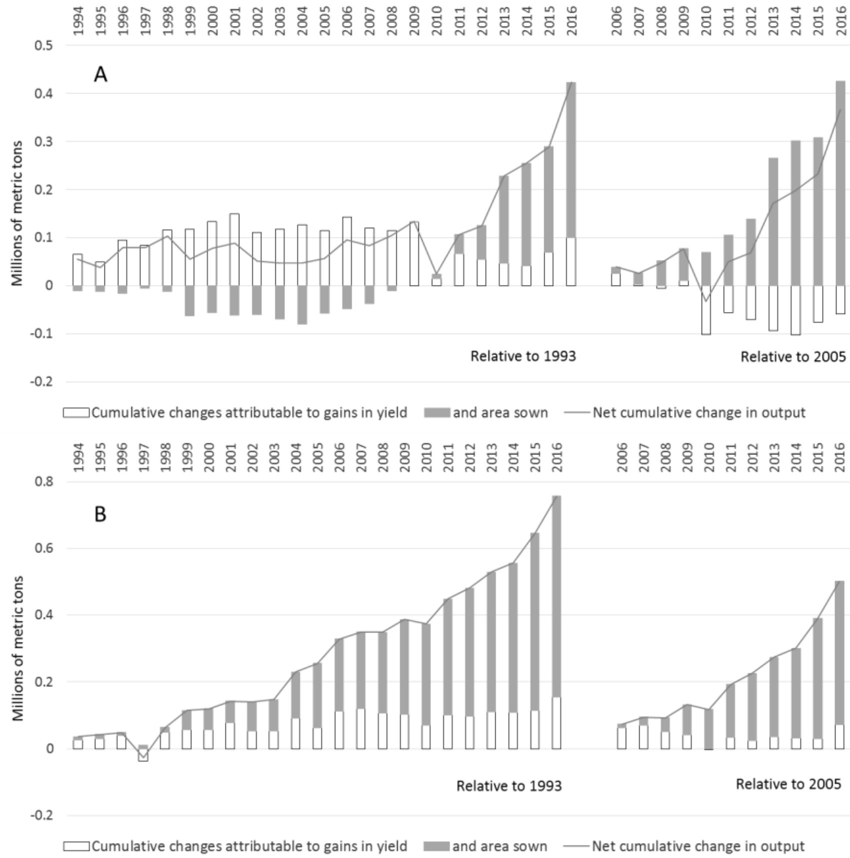
Fig A2. Cumulative changes in output of irrigated (A) and rainfed (B) sorghum attributable to yield and area-sown changes



Source: Authors' estimates based on SIAP data (see Methods and data)

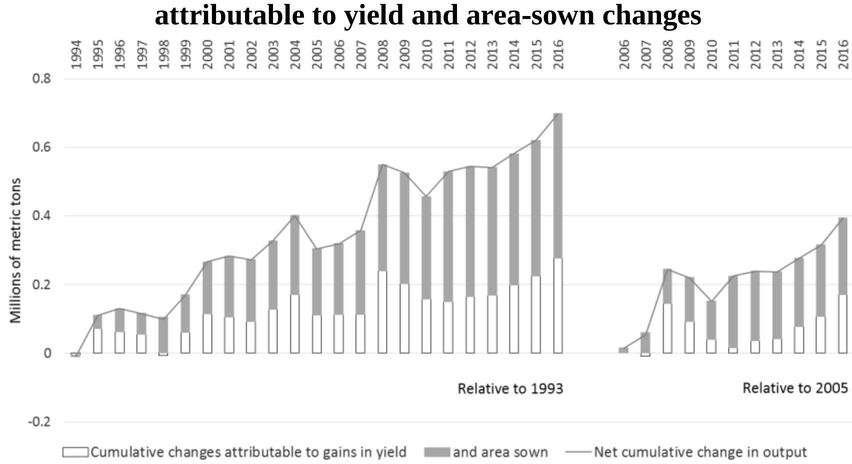
continuously since the onset of NAFTA, the first three have had a lackluster performance (Fig. A3 to A7).[xxxvii] Rainfed avocado has experienced exponential growth, its output rising 287% since 1993, with area expansion having an increasingly important role over time (Fig A3). That is, yields' contribution to output growth decreased from 42% prior to 2005, to 19% since then. Similarly, rainfed lemons have seen a 280% increase in output; but in this case, yield gains played nearly the same role prior to 2005 (contributing 39% of growth) and after (30%) (Fig A4).

Fig A3. Cumulative changes in output of irrigated (A) and rainfed (B) avocado attributable to yield and area-sown changes



Source: Authors' estimates based on SIAP data (see Methods and data)

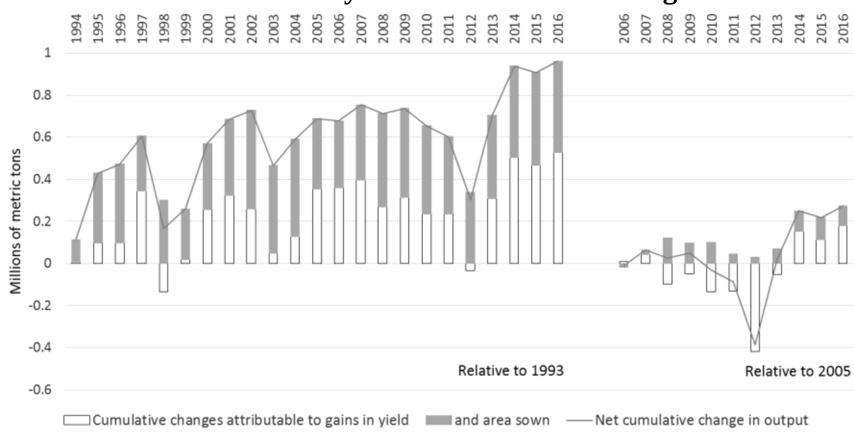
Fig A4. Cumulative changes in output of rainfed lemon attributable to yield and area-sown changes



Source: Authors' estimates based on SIAP data (see Methods and data)

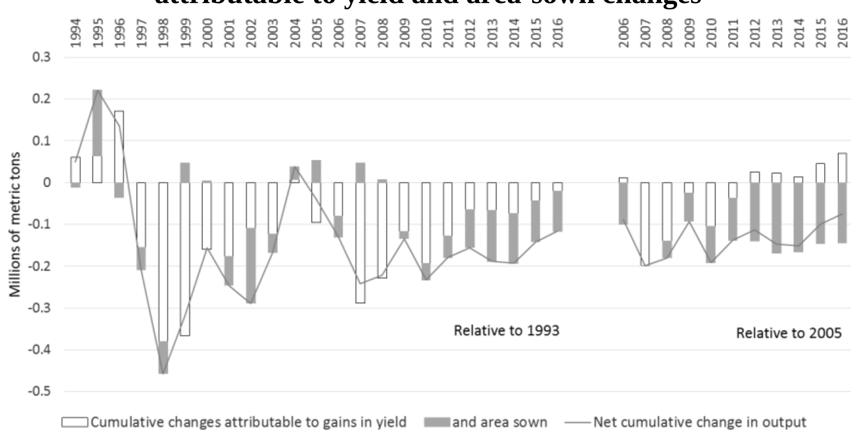
In irrigated areas, only chili peppers, and to some extent tomatoes, can claim an undisputed primacy in terms of land use, output and value. Between 1993 and 2016, their volume increased 155 and 104%, respectively, due mostly to gains in yields (Fig. A8, A9).

Fig A5. Cumulative changes in output of rainfed orange attributable to yield and area-sown changes



Source: Authors' estimates based on SIAP data (see Methods and data)

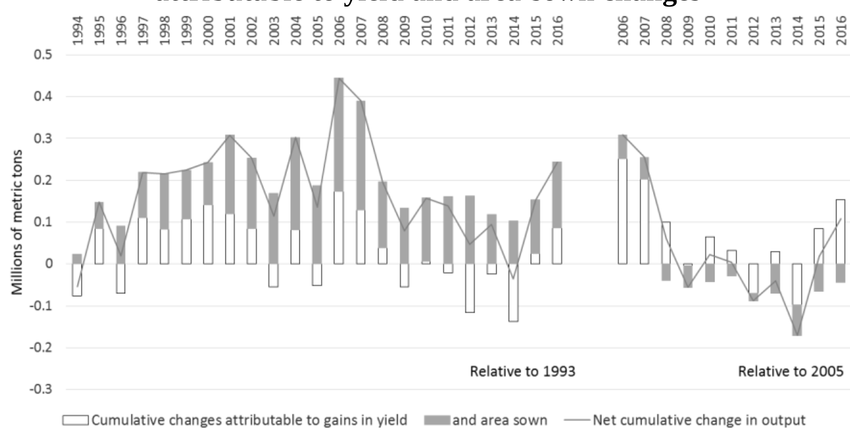
Fig A6. Cumulative changes in output of rainfed banana attributable to yield and area-sown changes



Source: Authors' estimates based on SIAP data (see Methods and data)

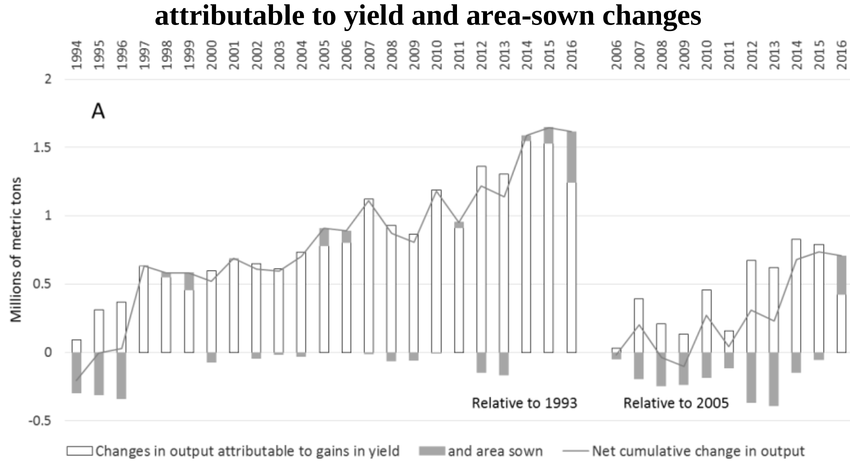
Tomatoes' area expansion contributed an average 6.4% of output growth prior to 2005, but otherwise, area contraction has represented a loss of potential output for both crops. In 2016, tomatoes continued as the most valuable specialty crop under irrigation but had descended to sixth place in terms of area behind lemons, oranges, mangoes and avocados. Of these, only avocado presently figures among the five most valuable irrigated fruits and vegetables. Its production increased 95% between 1993 and 2016, mostly during the last decade, with yield gains accounting for all growth prior to 2005 and area expansion for all growth since then (Fig A3). Other increasingly valuable specialty crops have been asparagus, blackberries and strawberries, whose area expansion has accelerated, contributing 23, 57 and 100% of output growth since 2005.

Fig A7. Cumulative changes in output of rainfed mango attributable to yield and area-sown changes



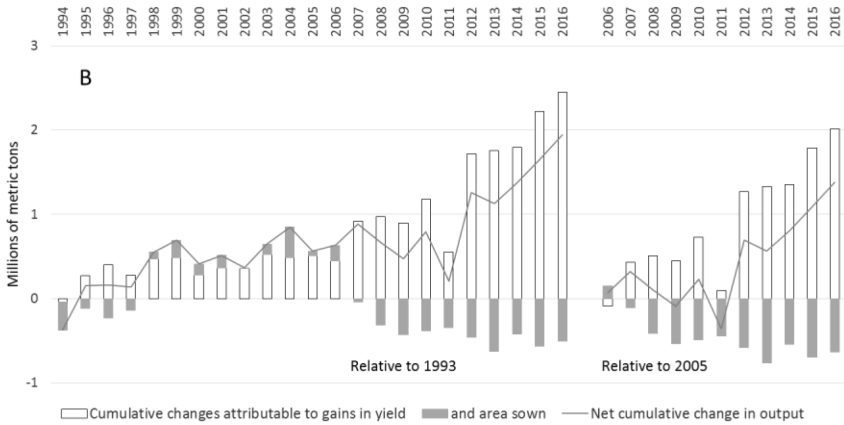
Source: Authors' estimates based on SIAP data (see Methods and data)

Fig A8. Cumulative changes in output of irrigated chili pepper attributable to yield and area-sown changes



Source: Authors' estimates based on SIAP data (see Methods and data)

Fig A9. Cumulative changes in output of irrigated tomato attributable to yield and area-sown changes

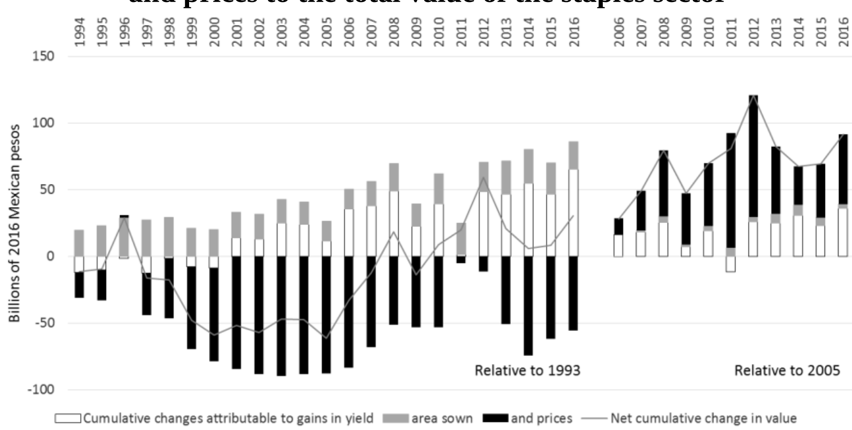


Source: Authors' estimates based on SIAP data (see Methods and data)

Crop value. Corn's expansion across rainfed areas between 1994 and 1997 largely offset its sharp contraction and wavering yields in irrigated areas. Although the total area under corn began sliding down after 1997, yield improvements kept its output remarkably stable through the end of the 20th century. The loss of 45% of the corn sector's value during NAFTA's early years was thus due entirely to falling prices (Fig. 3). Until 2005, rising yields barely counterbalanced the unrelenting fall in prices. Since then, the crop´s value has undergone three separate growth cycles with short periods of relative decline between them. Its value first rose 96% between 2005 and 2008, thus recovering its pre-NAFTA level. Surges in price and yields were responsible for 65 and 35% of this rise in value, respectively, while the total area in corn continued to slide downward. The crop´s value then declined 21% in 2009 due mostly to yield losses, but rose an additional 40% between 2009 and 2012, with price and yield gains again explaining 64 and 36% of growth. It declined once more in 2013 and 2014, 24% in total, due again to falling prices, but then rose 29% in the next two years with yields, prices and area responsible for 57, 27 and 17% of growth, respectively. At this point, the crop´s value was 114% greater than a decade earlier, but only 7.8% above its level in 1993.

In sum, prices and yields accounted for 68 and 32% of value gains in average since then. Yet differences between rainfed and irrigated production are noteworthy. Since 2005, rainfed cropland under corn has contracted 8%, but it has increased 20% in irrigated areas. In rainfed areas, higher prices and yields have contributed 59 and 41% of annual value gains since 2005, respectively; under irrigation, their contribution has been 80 and 15.5%, while area expansion accounts for the remaining 4.5%.

Fig A10. Contribution of cumulative changes in yields, area sown and prices to the total value of the staples sector



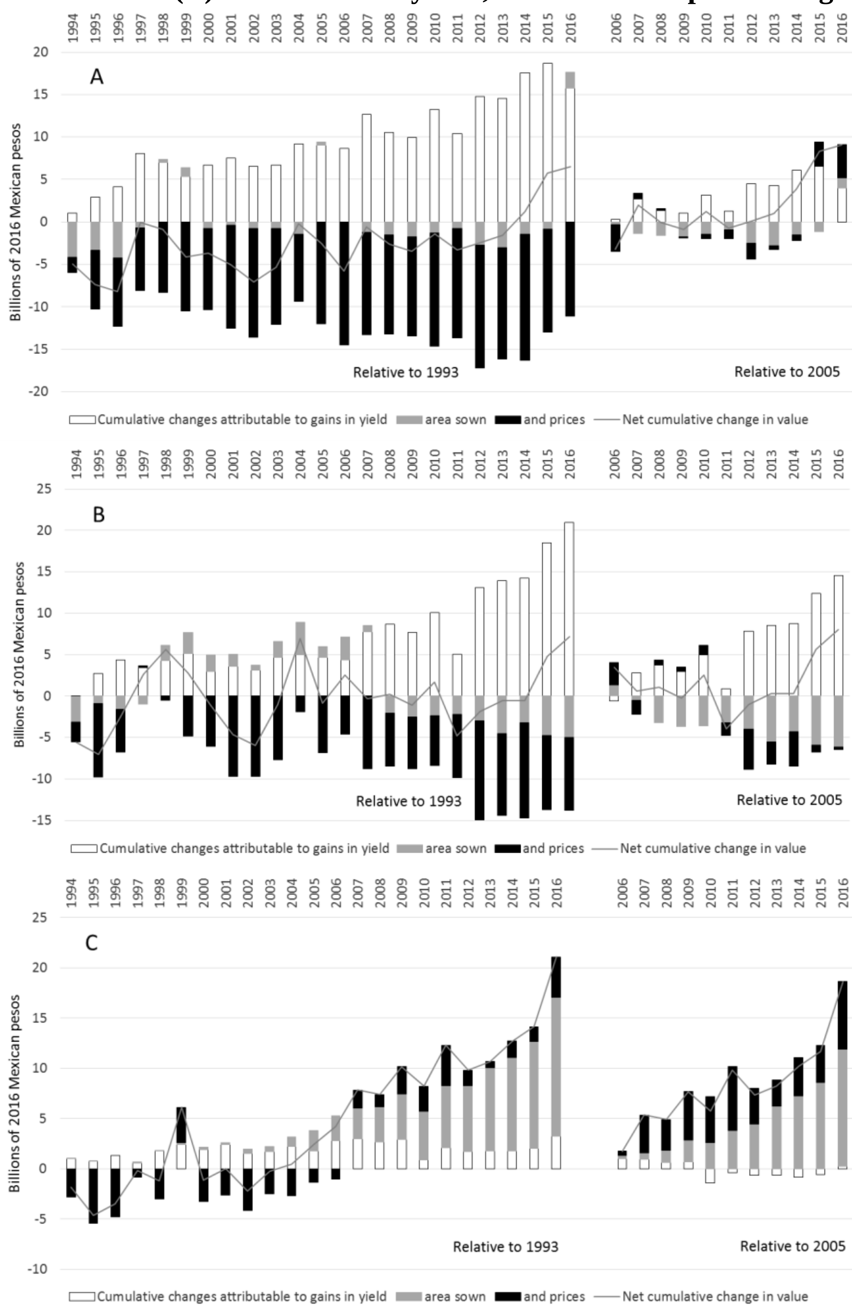
Source: Authors' estimates based on SIAP data (see Methods and data)

The rest of the staples sector has had a very different performance under NAFTA (Fig. 4). In irrigated areas, it did not lose value as a whole (relative to 1993) until 1999, and then not for long or more than 21%.[xxxviii] Its decline was entirely due to falling prices, while area expansion and yield gains represented an average 65 and 35% of gross value growth up to 2005. The sector recovered rapidly, growing 95% in the next eight years, but then lost 23% of its value mostly to declining prices in the three years after the 2012 price surge. Overall, since 2005, an average 64% of its growth has depended on favorable prices, 26% on area expansion, and only 10% on yield gains. In rainfed areas, by comparison, since 2005 the value of the staples sector excluding corn grain has increased even more than under irrigation, with prices, yields and area contributing 60, 27 and 13% of growth in average.

As regards fruits and vegetables, between 1993 and 2005, the gross value of the tomato and chili pepper harvests declined 4.4 and 15%, respectively, despite their output having increased 35 and 71% (Fig. A11). More precisely, during NAFTA's first decade, their value oscillated around the 1993 mark for tomatoes, and below that mark for chili peppers. All three factors—i.e., prices, yields and land area—contributed concurrently to these cycles, but most important was by far the influence of price fluctuations; between 1993 and 2005 prices decreased 29% for tomato and 50% for chili peppers. While changes in yields had in general a positive effect for both crops between 1993 and 2005, area had contrasting effects, adding value to tomatoes while subtracting it from chili peppers. In contrast, after 2005, both crops' value tended to stabilize, with output growth offsetting further price decreases. After 2013, large increases in both productivity and prices have raised these crops' total value by 40 and 28%, respectively. As for avocados, their value also decreased with their price after 1993 (Fig. A11). A constantly increasing output—80% of which was due to yield gains—did not entirely offset the effect of falling prices until a decade into NAFTA. Yet, despite faltering yields, the crop's total value has risen almost constantly since 2005, 160% in total; area and price increases have accounted for 53 and 47% of this growth.

Trends in rainfed and irrigated areas have differed noticeably. For instance, the value of both rainfed tomatoes and chili peppers has not increased but decreased, 36 and 43% since 2005, with stagnant or decreasing yields unable to offset the large contraction of land under both crops. In fact, by 2016, rainfed production accounted for only 5 and 4% of these crops' total value, down from 19% in 1993. As opposed, the value share of rainfed production of avocadoes has increased from 36 to 54%. Although this pattern has largely

Fig A11. Cumulative changes in the total value of chili peppers (A), tomatoes (B) and avocados (C) attributable to yields, area-sown and price changes



been the result of area expansion, yields have contributed 10% of rainfed value growth in average since 2005, while they have represented a 20% loss of value under irrigation.

As to fruits and vegetables as a whole, the sector's 22% loss of value, between 1993 and 1995, was due almost entirely to lower prices (Fig. 5). By 2005, yield and area gains had contributed much to its recovery yet did not entirely offset the effect of recurrent price decreases; the sector's value still remained 5.5% below its pre-NAFTA level. Since 2005, its value has risen 79%, with yields, prices and area contributing 50, 27 and 23% of growth in average. However, rainfed production has depended mostly on prices for growth, i.e., 51% since 2005, with yields contributing only 27%. While irrigated production surpassed its pre-NAFTA value conclusively in 2006, rainfed production did not do so until 2013.

[xxxv] Two-point estimates of growth rates suggest the volume of corn grain and wheat—i.e., the main grains for human consumption—increased, between 1993 and 2016, at average annual rates of 1.9 and 0.3%, respectively; sugar cane and barley—ingredients of processed foodstuffs—increased at rates of 1.2 and 2.6% per year. The highest rates were those of forages such as sorghum, corn forage and oats, which increased at rates of 2.9, 5.6 and 6.7%, respectively. Negative rates were observed for beans (-0.7%), rice (-0.5%) and oat grain (-0.6%), while soybeans grew an average 0.1% per year. Among major fruits and vegetables, the volume of oranges, mangoes and chili peppers increased at average annual rates of 2.0, 2.2 and 3.6%, respectively; avocados and lemons at rates of 4.4 and 5.4%, while minor specialty crops such as strawberries, asparagus and blackberries grew at annual rates of 7.2, 10.1 and 19.7%, respectively. Bananas experienced the lowest growth rates among major fruits and vegetables, at 0.3% per year.

[xxxvi] This description of irrigated corn area is based on a structural break test showing five distinct phases with the following annual rates of change: $-15x10^3$ ha/y ($p<0.05$) for 1980-1989; $203x10^3$ ha/y ($p<0.01$) for 1989-1994; $-139x10^3$ ha/y ($p<0.05$) for 1994-1999; $-49x10^3$ ha/y ($p<0.01$) for 1999-2011; $13x10^3$ ha/y ($p=0.81$; type II error $\beta=0.99$) for 2011-2016.

[xxxvii] All three crops have experienced periodic, severe contractions in output due to sudden drops in yields—up to 16 and 17% per year for oranges and mangoes, and 25% for bananas. Between 1993 and 2016, the volume of the first two increased 45 and 29%, mostly before 2005, while bananas' decreased 9.5%. A persistent loss of productivity accounted, in average, for 8884% of decreases in bananas prior to 2005; since then, 79% of decreases have been associated with area contraction. The expansion of orange groves was responsible for an average 69% of output growth prior to 2005 and 100% since then. As for mangoes, 74% of growth, in average, was due to area expansion up to 2005, but all growth since then has been due to yield gains.

[xxxviii] In comparison, irrigated corn grain lost 62% of its pre-NAFTA value and took 19 years to recover it.