U.S. Employment Exposure to Domestic and Foreign Tariff Changes under NAFTA

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Abstract

Literature examining the effects of changes in trade agreements and import competition on United States (U.S.) employment and wages has focused primarily on non-agricultural industries and tariffs on U.S. imports. We propose a method for measuring worker exposure to changes in agricultural tariffs using a newly developed county-level dataset of employment shares by crop and livestock type. We apply the method to examine the spatial concentration of U.S. county-level employment-weighted exposure to changes in tariffs caused by the North American Free Trade Agreement (NAFTA). Results reveal noteworthy decreases in average U.S. county-level crop and livestock employment exposure to Mexican import tariffs on U.S. products. Findings also show spatial variation in U.S. employment exposure to changes in Mexican import tariffs on U.S. agricultural and non-agricultural goods. Changes in county-level employment exposure to U.S. and Canadian import tariffs after NAFTA implementation are relatively minor given low initial tariff rates prior to the agreement.

Introduction

There is renewed demand for economists to examine the efficiency and distributional implications of trade policies for labor markets and local economies. Globally, barriers to trade increased in recent years (Constantinescu et al., 2019). This includes increased tariffs from trade wars and barriers to the movement of people and goods implemented in response to COVID-19 (Beckman and Countryman, 2021; Beckman, Baquedano, and Countryman, 2021; World Trade Organization, 2020). Previous literature examines the effects of trade liberalization on employment and wages in non-agricultural industries of the United States (U.S.) (Autor, Dorn, and Hanson, 2013; Autor et al., 2014; Hakobyan and McLaren, 2016). However, the lack of detailed analysis of agricultural sectors from this literature has important implications, especially for rural communities where agricultural exports are an important source of income (Zahniser et al., 2017). This paper proposes a method for measuring worker exposure to changes in agricultural tariffs using a newly developed county-level dataset of employment shares by crop and livestock[1] type. We use this novel dataset to examine U.S. worker exposure to domestic and foreign import tariff changes that resulted from NAFTA. We differentiate crop, livestock, and non-agricultural tariff changes and compare the magnitude of the employment-weighted changes across these sectors. Finally, we illustrate the spatial distribution of U.S. worker exposure to changes in both agricultural and non-agricultural tariffs.

Neoclassical economic theory assumes that labor will migrate across industries in response to trade liberalization, from industries or locations where the country does not have a comparative advantage to industries or locations where the country does. However, empirical studies show that there are high frictions to labor mobility following changes in trade policy or exposure to import competition (Autor, Dorn, and Hanson, 2013; Autor et al., 2014; Dix-Carneiro and Kovak, 2015, 2017; Hakobyan and McLaren, 2016; Topalova, 2007, 2010). Autor et al. (2014) find heterogeneous effects of import competition on worker mobility in the U.S. across workers' initial skills and wages. Low-wage workers initially employed in industries that experienced high import competition tended

[1] Livestock includes live animals and animal products.

to migrate to firms within the same sector, thus experiencing multiple employment disruptions as import competition increased over time. In contrast, high-wage workers were better able to migrate to higher performing industries over the long run, experienced greater wage growth, and were less likely to take public disability benefits than low-wage workers. These findings show that trade liberalization can sometimes exacerbate economic inequalities. Furthermore, labor market impacts of trade policies can be persistent. Wages and formal sector employment were still depressed in industries and locations exposed to greater import competition more than 20 years after Brazil cut import tariffs in a large-scale trade liberalization effort (Dix-Carneiro and Kovak, 2017). Additional research to understand how trade liberalization or protectionist policies implemented by a country or its trade partners affect labor markets in urban and rural communities across agricultural and non-agricultural sectors is imperative for informing policy, enhancing labor market opportunities, and anticipating changes in labor migration.

Previous literature examining the effects of NAFTA on worker wages in the U.S. shows that NAFTA depressed wages in industries that experienced large declines in tariff protection from 1990-2000 (Hakobyan and McLaren, 2016). Service sector workers also had depressed wages if they were employed in locations where a large share of the workforce was employed in industries that had large declines in U.S. import tariffs during NAFTA. However, the agricultural sector was deliberately excluded from the analysis of Hakobyan and McLaren (2016) due to lack of detailed data on labor use by crop and location. While their findings are robust to the inclusion of the aggregate agricultural industry, agricultural tariffs changed substantially during NAFTA and this may have had unintended consequences across agricultural sectors. For example, the sector labeled "canned, frozen, and preserved fruits and vegetables" was the third most protected industry in the U.S. in 1990.[2] After adjusting for Mexico's Revealed Comparative Advantage[3] in production of goods in each industry, it drops to the fifth most protected industry, and

[2]See Table 2 in Hakobyan and McLaren (2016).

[3]Mexico's Revealed Comparative Advantage is Mexico's share of trade with the rest of the world in the select industry divided by Mexico's share of trade with the rest of the world in all goods. A Revealed Comparative Advantage greater than 1 means that Mexico exports more of the good than the average product (Hakobyan and McLaren, 2016).

agricultural crop production becomes the eighth most protected industry (Hakobyan and McLaren, 2016).

In rural communities, where agriculture is a more dominant employer, changes in agricultural tariffs could have important labor market implications that are not fully understood when only controlling for the effects of aggregate agricultural labor exposure to tariffs. Crop aggregations mask important variation in the magnitude of tariff changes and labor intensity across individual crops. Since the U.S. is a major exporter of agricultural goods, changes in foreign tariffs on U.S. goods could have important labor market effects in the U.S. Even though some crops lost protection with implementation of NAFTA, others gained access to foreign markets. Therefore, it is important to consider the labor market effects of reductions in both domestic and foreign import tariffs.

Little research has been devoted to understanding the effects of trade liberalization on employment and wages in rural communities of developed countries with a large agricultural presence. One notable exception is Autor et al. (2024), who show that Chinese import tariffs imposed on U.S. agricultural goods during the 2018-2019 trade war negatively affected U.S. agricultural employment while U.S. worker exposure to U.S. import tariffs on non-agricultural goods had no sizeable effect. The authors measure U.S. employment by sector using 6-digit North American Industry Classification System (NAICS) codes in the Quarterly Census of Employment and Wages (QCEW) and impute employment by sector and commuting zones using higher aggregations of industries or geographic locations when the QCEW data are suppressed. Furthermore, He (2020) uses farm employment data from QCEW and the U.S. Bureau of Economic Analysis to estimate the impact of agricultural exports on local employment. He (2020) finds that a 1% increase in agricultural exports increases farm employment by 0.302% and has no statistically significant impact on nonfarm labor.

We provide an alternative method to measuring crop- and livestock-specific employment exposure to both domestic and foreign tariffs at detailed geographic levels by using precise crop and livestock (including animal products) classifications in the U.S. Census of Agriculture. Our method is less reliant on QCEW data, which prior to 2004, did not report the number of establishments in suppressed industry observations and prior to 2001, did not distinguish between observations that were suppressed versus zero. The count of establishments in industries with suppressed labor observations is critical to the imputation methods of Autor et al. (2024), making their methods impossible to replicate in years prior to 2004. There may be other advantages to our alternative agricultural employment measure. For instance, our method reduces concerns of underreporting of unauthorized immigrant agricultural workers in the QCEW data. Finally, our method assigns agricultural workers of different contract types, including employees of farm labor contractors (FLCs), to specific crops. For these reasons, our method provides some advantages, especially for examining labor exposure to shocks prior to 2004.

We create a unique dataset that combines trade data detailed to the 6-digit Harmonized System (HS) product code with county-level acreage and production data for specific crops and livestock in the U.S. Census of Agriculture, labor inputs by crop from crop enterprise budgets, and wage and employment data from the QCEW. We measure county employment exposure to changes in tariffs using methods similar to Topalova (2007) and Topalova (2010), additionally weighting tariffs by the trade partner's Revealed Comparative Advantage (RCA) as in Hakobyan and McLaren (2016). We show that, on average, the decrease in U.S. tariff protection under NAFTA was much smaller in magnitude than the decrease in tariffs that Mexico imposed on imports of U.S. goods. Furthermore, the decrease in Mexican import tariffs on crops and livestock was larger in magnitude than its decrease in non-agricultural import tariffs. Canadian import tariffs on U.S. goods were relatively low prior to NAFTA, so the magnitude of changes was much less than for Mexican import tariffs. Finally, we show that in many counties, the employment-weighted workforce exposure to reduced foreign import tariffs on U.S. crops was larger in magnitude than changes in workforce exposure to reductions in U.S. or foreign import tariffs on non-agricultural goods following the roll-out of NAFTA. The geographic spread and magnitude of changes in worker exposure to foreign import tariffs on U.S. goods varied substantially across crops, livestock, and non-agricultural goods.

Our findings illustrate the importance of investigating labor market exposure to tariff changes in each of these sectors distinctly.

Our focus on the agricultural sector is an important distinction from previous literature since the U.S. was a net exporter of agricultural products during the roll-out of NAFTA, and employment and wages in agricultural communities might benefit from reduced foreign tariffs on U.S. goods. Although previous literature shows that employment and wages declined following the roll-out of NAFTA in locations where labor exposure to reduced U.S. tariffs on non-agricultural industries was greater (Hakobyan and McLaren, 2016), to understand the full implications of NAFTA and other trade agreements, empirical investigation needs to account for changes in workforce exposure to both U.S. and foreign import tariffs. In this paper, we develop data and methods to more accurately measure employment exposure to tariff changes in the agricultural sector and further explore how labor exposure to changes in U.S. and foreign import tariffs across crop, livestock, and non-agricultural sectors compared during the roll-out of NAFTA. Our findings suggest that connections between tariffs and labor might be more complex than previous literature implies, and therefore merit further exploration.

This paper proceeds as follows. In the next section, we review the relevant literature. Next, we describe the data. In the following section, we calculate county employment exposure to domestic and foreign import tariffs. Then we illustrate spatial variation in changes in county exposure to domestic and foreign import tariffs by sector during NAFTA implementation. We discuss potential policy implications of sector-specific labor exposure to trade policy, and lastly, we conclude.

Related Literature

This section knits together literature on the distinct characteristics of agricultural and rural labor markets in the U.S., the labor market effects of domestic and foreign policy changes, and the medium- to long-term effects of NAFTA and other trade agreements. Although it is well understood that NAFTA had important implications for the U.S. agricultural sector (Zahniser et al., 2015; Zahniser and Link, 2002; Zhao, Devadoss, and

Luckstead, 2020), we know of no other analyses that measure worker exposure to changes in foreign and domestic import tariffs during NAFTA using detailed employment data disaggregated across space (by county) and by crop and livestock types. Nevertheless, Autor et al. (2024) show that the agricultural sector's exposure to changes in foreign import tariffs can have important implications for rural employment, and detailed measures of employment by crop type are essential for careful analysis of the labor market effects of trade policies.

Agricultural and rural labor markets are distinct from those in metro areas of the U.S., and changes in employment opportunities can have a myriad of consequences that are difficult to predict. For example, decreased employment and wages are associated with increased opioid overdoses within metro and non-metro counties of the U.S. Betz and Jones (2018) find differential effects by skill level, gender, and race, which suggests that both the number and types of jobs available in a region are important. Agricultural employment could also have important implications for other social welfare outcomes. Increased seasonal fruit, vegetable, and horticultural employment within U.S. counties is associated with a significant decrease in property crime rates, even after controlling for county-by-year fixed effects (Charlton, James, and Smith, 2022). Increased economic opportunities likely deter crime during labor-intensive seasons of farm production, even if more people migrate into the region. This is consistent with evidence that unemployment and wages influence crime rates (Gould, Weinberg, and Mustard, 2002; Yamada, Yamada, and Kang, 1993), though James and Smith (2017) find that an economic boom can also increase crime rates. These findings demonstrate the importance of understanding how rural and urban labor markets are exposed to domestic and foreign trade policies.

Agricultural labor markets have important location and time dimensions, which are often determined by conditions like weather (Fisher and Knutson, 2013). Overall employment rates might consequently mask important distinctions in agricultural labor markets. Farm workers have become less migratory over time (Fan et al., 2015). Fan et al. (2015) find that from 1999-2009, the share of crop workers who migrated decreased by more than 60%. These trends have important implications for the ability of agricultural labor markets to adjust quickly and smoothly to changes in labor demand such as following changes in foreign and domestic trade policies. The use of FLCs to match workers to temporary or seasonal jobs, thus reducing labor market frictions, is relatively common in California and Florida where labor-intensive specialty crops are grown in greater concentrations, but less common in other regions of the U.S. (Fisher and Knutson, 2013). Although detailed data on crop-specific employment are sparse, research on farm labor markets needs to account for important variation across crops and where they are grown since workers are not perfectly mobile.

There is evidence that farm workers do not immediately migrate to other sectors as relative wages in other sectors rise, consistent with the notion that workers associate an option value with remaining in their current sector of work (Önel and Goodwin, 2014). However, Richards and Patterson (1998) show that workers migrate more rapidly from agricultural to non-agricultural sectors than the reverse. Following NAFTA, Boucher et al. (2007) find that migration from rural Mexico to U.S. farms increased, but there has been little investigation of agricultural worker exposure to changes in foreign and domestic tariffs.

While several studies investigate the effects of import competition on U.S. employment, it is important to consider both worker exposure to domestic import tariffs and exposure to foreign import tariffs levied on U.S. exports. Feenstra, Ma, and Xu (2019) investigate overall state-level employment effects of import competition from China and find that export expansion creates employment opportunities that offset jobs lost in import-competing industries. However, Autor, Dorn, and Hanson (2016) and Kondo (2018) find unequal distribution of employment effects. They find that the magnitude of the negative effect on workers in import-competing industries was larger than the magnitude of the positive employment effects for workers in export-oriented industries. While these studies provide insights into overall employment effects of trade exposure, agriculture is either not accounted for or is aggregated into one combined employment sector. Furthermore, studies show that NAFTA-related tariff reform for agricultural products led to trade creation that exceeds trade diversion (Kennedy and Rosson, 2002; Burfisher, Robinson, and

Thierfelder, 2001), highlighting the need to explicitly account for changes in agricultural and non-agricultural tariffs faced by both U.S. imports and exports when considering rural employment exposure to trade protection.

Related to the impacts of tariff policies, the literature has also explored the rural development and labor market implications of exports. For example, USDA multipliers suggest that agricultural exports have positive effects in rural areas for both agricultural and non-agricultural sectors (He, 2020). Existing empirical studies confirm that agricultural exports benefit farmers and owners of farm assets (Weber et al., 2015; Kilkenny and Partridge, 2009), but they find limited evidence of spillovers into non-agricultural sectors. Consistent with this, He (2020) finds that agricultural exports increase farm employment but do not lead to significant increases in non-farm employment.

Given the unique features of U.S. agricultural labor markets, NAFTA likely had distinct effects on employment and wages that vary across U.S. crops, livestock, and regions of employment. Studies that aggregate agricultural employment (e.g., Hakobyan and McLaren (2016)) mask this variation. Furthermore, research that accounts for the effects of improved access to foreign markets through the reduction of foreign import tariffs on U.S. goods is essential. Researchers have measured the effects of U.S. tariff changes on employment and wages in Canada and Mexico using detailed geographic employment data (Chiquiar, 2008; Feliciano, 2001; Kovak and Morrow, 2022). However, literature measuring the effects of changes in foreign import tariffs on U.S. employment and economic activity (e.g., Congress (2003); Burfisher, Robinson, and Thierfelder (2001)) during NAFTA do not closely examine spatial variation in labor market exposure.

We contribute to the existing literature on labor markets and trade policy by examining U.S. agricultural and non-agricultural employment exposure to changes in U.S. and foreign import tariffs during a major trade agreement that began in the 1990s. We use a method that accounts for the importance of specific commodities within local agricultural labor markets. One of the few papers that investigates agricultural employment exposure to changes in trade policy in a developed country is Autor et al. (2024), which examines the effects of the U.S.-China 2018 trade war on agricultural employment. We build on this literature by developing an alternative measure of agricultural employment by crop and livestock type. Our measure offers several advantages, particularly for measuring crop-specific employment shocks prior to 2004.

First, the method described in Autor et al. (2024) relies on information about the number of suppressed observations. In 2001 and following years, QCEW began reporting if missing employment data were the result of zero employment or because of data suppression required to protect the privacy of individual firms. Prior to 2001, researchers do not know if missing employment is because of suppression or because of zero employment. Furthermore, in 2004, QCEW began recording the number of establishments even when all other data for the county-NAICS or state-NAICS pair are suppressed. Autor et al. (2024) use these establishment counts to more precisely allocate employment across missing values, but this is only possible in 2004 and later. Given these limitations in the QCEW data prior to 2001 and 2004, we would not be able to estimate base year tariff exposure prior to NAFTA using the methods employed by (Autor et al., 2024).

Second, QCEW only records employment for workers who are reported for Unemployment Insurance, and there is concern that many agricultural workers might be omitted. A large share of crop workers is unauthorized (estimated around 50 percent in many years in the National Agricultural Workers Survey (NAWS)). While many unauthorized immigrants use borrowed Social Security numbers and would thus be counted as any other worker in Unemployment Insurance, we do not know how many might be omitted or whether omission varies across crop types. Furthermore, small farms are not required under federal mandate to report employment.[4] Our methods for measuring labor hours by crop type mitigate concerns related to the misreporting of unauthorized workers in the QCEW and underreporting by small farms.

[4] The 1976 amendments to the Federal Unemployment Insurance Tax Act require agricultural employers to report agricultural workers as follows: "The 1976 amendments covered agricultural labor if performed for an employer who, in any calendar quarter in the current or preceding calendar year, paid cash remuneration of $20,000 or more to individuals employed in agricultural labor. The 1976 amendments also apply to employers who, on each of some 20 days in 20 different weeks during the current or preceding calendar year, employed at least 10 individuals in agricultural labor." (Source: U.S. Bureau of Labor Statistics (2024))

Finally, using crop enterprise budgets provides us with slightly more disaggregated crop-specific information and does not distinguish employees of farm labor contractors (FLCs) but assigns these workers to specific crops like any other worker. In the QCEW, FLCs have a NAICS industry code (NAICS 115115) and it is unknown what crops they work on. Since FLCs accounted for more than 14% of the crop workforce in 2019 and were the fastest growing share of farm workers (Costa and Martin, 2020), and in 1990, they accounted for about one-third of crop employees in California (Martin and Taylor, 1990), it is important to include FLC workers in analysis of agricultural employment, especially in states like Florida and California where FLCs are more prevalent. Our methods also disaggregate other NAICS codes that cluster several crops. For example, NAICS codes combine many tree nut crops into a single sector (111335) while we treat different tree nut crops (e.g., pistachios, almonds, walnuts) separately.

This analysis provides many important contributions to the trade and agricultural labor literature. Importantly, we compare employment exposure to both U.S. and foreign import tariff changes during NAFTA, which was a notable trade agreement in that it eliminated most barriers to trade between 3 countries and remained in effect for 26 years until it was replaced by the U.S.-Mexico-Canada Agreement in 2020. Understanding how worker exposure to tariff changes during the roll-out of NAFTA varied across sectors and geographic locations has important implications for learning about and anticipating the potential social impacts of this and future trade policies.

Data

We create a unique dataset of county-level tariff exposure based on the number of employees in different sectors. We combine data from the World Integrated Trade Solution (WITS) database, CEPII[5] MAcMap HS6 (Guimbard et al., 2012), the U.S. Agricultural Census, the Bureau of Labor Statistics QCEW, and farm-level crop enterprise budgets published by various U.S. universities. We create the first national dataset to our knowledge with county employment shares by individual crops that do not depend on employer-

[5] CEPII is an acronym for *Centre d'études prospectives et d'informations internationales.*

provided Unemployment Insurance reports as in the QCEW. We combine these data with employment shares in non-agricultural and livestock products, and U.S., Canadian, and Mexican import tariffs by product and year.

Trade and Tariff Data Construction

We obtain pre-NAFTA trade and tariff data from the WITS database, which accesses major international trade databases—the United Nations (UN) Comtrade database for trade and the United Nations Conference on Trade and Development (UNCTAD) Trade Analysis Information System (TRAINS) database for tariffs. We employ tariff data for the post-NAFTA period from Guimbard et al. (2012), which provides applied rates of protection in 2010. Applied rates from this source were first available in 2001, and we use tariff data from 2010 because NAFTA tariff changes were fully rolled out by 2010 (Zahniser et al., 2015).

We use the WITS database to construct pre-NAFTA tariff rates. To account for missing observations for pre-NAFTA tariff data, we include the lowest recorded tariff rate from 1991-1994 in the WITS database. For Canada, the only available tariff data were from 1993, for Mexico, data are only available from 1991, and for the U.S., tariff data were available in 1992 and 1993. From the WITS database, We also use annual bilateral trade flows at the Harmonized System (HS) 6 product level in 1992. We use the HS6 product code level because we can more precisely match tariffs to specific crops and livestock. We use bilateral import and export trade values in nominal U.S. dollars from Canada, Mexico, the U.S., and the rest of the World. We merge the trade flow data with bilaterally applied import tariffs at the HS6 level.

For some products, no tariff is reported in the pre-NAFTA period, and a positive tariff is reported in 2010. This occurs most frequently for Canadian livestock tariffs (10.96% of livestock product codes imported from the U.S.) and for U.S. livestock tariffs (5.93% of livestock product codes imported from Mexico or Canada). Fewer than 1% of product-codes in crops and livestock showed an increase in U.S. import tariffs. No crops and fewer than 1% of non-agricultural products had an increase in Canadian tariffs on imports from the U.S. No livestock products, 3.5% of crop products, and fewer than 1% of non-agricultural products had an increase in Mexican tariffs on imports from the U.S. Since the increase in tariffs appears to be the result of missing tariff observations pre-NAFTA, and the World Trade Organization (WTO) encouraged countries to convert non-tariff measures (NTMs) to tariffs during this time period (Daly and Kuwahara, 1998), we attribute the increase in tariffs to either missing data or tariffication of NTMs rather than an outcome of NAFTA. NAFTA was implemented to decrease trade barriers, so we replace tariff increases with zero change in tariffs between our pre-NAFTA and post-NAFTA observations.

To examine tariffs before and after NAFTA, we weight import tariffs by the comparative advantage of the trade partners to place greater weight on import tariffs for goods that the trade partner specializes in exporting. We do this using the Revealed Comparative Advantage (RCA) as defined in Hakobyan and McLaren (2016). The RCA is a measure of how much a country exports a good relative to total world exports of that good as a share of the country's share of total world exports in all goods. Specifically, let $k \in 1, ..., K$ be the index of goods for which we estimate employment. Some index numbers match to multiple HS6 codes. To aggregate multiple HS6 products to the index k, we sum trade flows within each industry k. The RCA is then calculated at the country-by-product, c-by-k, level using global trade data from 1992 as follows:

$$RCA_k^c = \frac{\frac{x_{k,1992}^c}{x_{k,1992}^{ROWc}}}{\frac{\sum_n x_{n,1992}^c}{\sum_n x_{n,1992}^{ROWc}}} \tag{1}$$

where $x_{k,1992}^c$ is country c's exports of good k to the rest of the world (ROW) excluding exports to the trade partner of interest (e.g., when calculating Mexico's Revealed Comparative Advantage for trade with the U.S., we exclude Mexico's exports of good k to the U.S.), and $x_{k,1992}^{ROWc}$ is total world exports of good k excluding bilateral trade between country c and the trade partner of interest. Thus the numerator is country c's share of world trade of good k excluding trade with the trade partner of interest. The denominator is country c's share of total ROW exports in all goods $n \in 1, 2, ..., k, ..., N$. The RCA is therefore country c's share of ROW exports of good k divided by country c's share of total ROW exports. If $RCA > 1$, then this indicates that country c specializes in production and trade of good k.

Let $j \in \{crop, livestock, non-agriculture\}$ index the three labor sectors of interest, where each industry k belongs to a sector j. We map crop and livestock products that involve minimal processing to crops and livestock, respectively (See Appendix Table A.1). For example, both wheat and wheat flour are mapped to wheat production. Both live cattle and fresh and frozen beef are mapped to cattle (we describe this mapping in more detail in the next section). We calculate the weighted mean import tariff that the U.S. imposes on country $c \in \{MX, CA\}$ for goods in sector j as follows:

$$\tau_{jt}^{USc} = \frac{\sum_{k \in j} \tau_{kt}^{USc} \cdot RCA_k^c}{\sum_{k \in j} RCA_k^c} \tag{2}$$

where τ_{kt}^{USc} is the tariff that the U.S. imposes on imports of goods in industry k from country c in year t calculated by taking the average tariff across all HS6 product codes in k weighted by their import value in base year 1992, and RCA_k^c is country c's Revealed Comparative Advantage in global exports of goods from industry k.

We similarly calculate the weighted mean import tariff that each country c imposes on the U.S. for goods in sector j as follows:

$$\tau_{jt}^{cUS} = \frac{\sum_{k \in j} \tau_{kt}^{cUS} \cdot RCA_k^{US}}{\sum_{k \in j} RCA_k^{US}} \tag{3}$$

In Figure 1, we plot the weighted mean tariffs by sector and trade partner pairs for pre- and post-NAFTA periods. While the U.S. decreased import tariffs on Mexican non-agricultural goods by about 2 percentage points on average, this is not nearly as large as the decrease in Mexican import tariffs on U.S. goods. In each sector, mean weighted Mexican import tariffs decreased by more than 10 percentage points. Changes in Canadian import tariffs on the U.S. and U.S. tariffs on Canada were relatively small in magnitude.[6]

Labor Data Construction

Lacking detailed employment data by crop and livestock type, we calculate crop and livestock employment by combining data from numerous sources detailed in Appendix 2. To find employment by crop of type k, we take detailed acreage data by crop from the 1992 U.S. Census of Agriculture. Although the Census of Agriculture does not record workers per crop, we can estimate total labor hours per crop in each county by multiplying acreage for each crop in the county by the labor hours per acre required to produce each crop for a representative farm. We take hours per acre from crop enterprise budgets published at various universities.[7]

For every crop k we compute the total implied crop labor hours in a county by taking the product of county level acreage of crop k and labor hours per acre for production of crop k based on the enterprise budgets. We sum labor hours across all crops and then find crop k share of total county crop labor hours as follows:

$$L_{ik}^{1992} = \frac{A_{ik}^{1992} \cdot \phi_k}{\sum_{k \in crop} A_{ik}^{1992} \cdot \phi_k} \tag{4}$$

where L_{ik}^{1992} is the share of crop employment in crop type k in county i in the base year 1992, A_{ik}^{1992} is acreage of crop type k in county i in the 1992 Agricultural Census, and ϕ_k is labor hours per acre for production of crop k calculated from the crop enterprise budgets.

One of the challenges in using crop enterprise budgets to estimate the labor intensity of crop production is that many tasks performed on farm are hired through custom operations, and the budgets do not always contain detailed labor input data. We spoke

[6]Figure 1 shows mean tariffs after setting observed increases in tariffs at the HS6 level to zero change. The unadjusted mean tariffs are in Appendix Figure A.1

[7]Enterprise budgets used to construct our dataset are cited in Appendix 2. We drew data from 122 crop enterprise budgets to construct our dataset.

with authors of UC Davis budgets to approximate percentages of costs for agricultural production activities like discing or spraying that can be attributed to labor, so that we can include these activities in total labor inputs even when they are written only as total custom line items. To the extent that these services have similar production technologies across the country and across crops, the estimates provided by these authors are a reasonable proxy for the labor per acre in these services. This represents an improvement over assuming that the labor cost share of custom contracted activities in crop production is 0.

We note that our method uses crop enterprise budgets from the 2010s and 2020s, but that tariff changes under NAFTA occurred in the 1990s and 2000s. If crop labor amounts per acre have changed significantly over time in different ways for different crops (e.g., through mechanization), our estimates may contain bias. However, the USDA Economic Research Service[8] finds that mechanization slowed or even reversed as of the 1990s in the U.S. Consistent with this, Alvarez-Cuadrado, Van Long, and Poschke (2017) examine shifts in capital-labor ratios in agriculture. Finally, Hamilton et al. (2022) show that profit maximizing firms in a labor market that is not perfectly competitive will be slow to adopt mechanical aids that complement labor because this would increase the demand for labor and put upward pressure on wages. They find that, despite available mechanical technologies that enhance labor productivity in strawberry production, mechanical adoption has been slow. They suggest that this explains why the productivity gap in U.S. agriculture has been persistent, and why technological advances have not "pushed" workers out of agriculture. Thus, evidence suggests that employer market power in the agricultural sector has disincentivized technology adoption and stabilized farm employment in some labor-intensive crops, including strawberries.

There are other potential sources of bias in our estimates of crop employment shares. For example, crop enterprise budgets are based on a sub-sample of farms that are not necessarily representative of each crop industry as a whole. To mitigate concerns about representativeness, we collect as many budgets as possible and use average labor intensi-

[8] https://www.ers.usda.gov/topics/farm-economy/farm-labor/

ties. This diminishes the importance of any one budget in influencing our results. Next, there could be geographic variation in labor intensities that our method misses. We explore if under- or over-estimates of crop labor per acre influence our results by performing a Monte Carlo analysis described in Appendix Section B. By randomly selecting from a distribution of labor intensities (independent by crop), we quantify how sensitive our estimates are to the estimated crop labor intensity. Results in Appendix Figure B.1 show how crop employment shares at the county level vary by U.S. census region. After taking 500 random draws of crop labor hours per acre, independently for each crop, we calculate crop employment-weighted mean tariffs in each county and calculate the coefficient of variation across all simulations. We plot the coefficient of variation by county in Appendix Figure B.2. The coefficients of variation are relatively small across the nation for all trade partner pairs. Finally, we present a series of .gifs in Figures B.3 to B.6 showing our main results for a random sample of 25 of the 500 Monte Carlo iterations used in the sensitivity analysis. While small variations exist, it becomes clear that the regions that are exposed to tariff changes remain consistent across iterations.

Even allowing for variation in the labor required to produce each crop, we obtain a robust estimate of the relative intensity of different crops. This leads to the overall robustness of our main results to the draw of specific crop labor intensities. In Appendix Figure B.7, we present the mean and 90% confidence interval for labor hours per acre for 15 crops. The method clearly distinguishes between labor-intensive crops like strawberries or oranges, highly mechanized crops like wheat, soy, or corn, and a range of crops in between, like almonds (mostly mechanized) and lettuce (relatively quick to hand-harvest compared to strawberries and most orchard fruits).

This approach to measuring labor use by crop does not rely on imputation of QCEW data as described in Autor et al. (2024). While measuring crop-specific labor intensity can be challenging, it offers an alternative approach to measuring agricultural labor's exposure to tariff changes. In the context of estimating NAFTA impacts, an alternative to QCEW imputation has several advantages as already described in the previous section on Related Literature.

For livestock employment shares, since we lack proxies of employment per animal, we approximate livestock employment shares with the share of total livestock value in the county for each animal (cattle, sheep, dairy, hogs, poultry, mink, and fish/aquaculture by type) in the 1992 Census of Agriculture.

For the non-agricultural sector, we use employment data from the QCEW. The QCEW includes data for all workers who worked or received pay during the pay period including the 12th day of the month and who were covered by the state Unemployment Insurance laws (and federal workers covered by the Unemployment Compensation for Federal Employees program). We use employment by 3-digit NAICS industry codes, including forestry and logging (NAICS 113) but excluding crop production (NAICS 111), support activities for crop production (NAICS 1151), livestock production (NAICS 112), fishing, hunting and trapping (NAICS 114), support activities for animal production (NAICS 1152), food manufacturing (NAICS 311), and beverage and tobacco product manufacturing (NAICS 312). Since there is suppression in the QCEW data, and we do not know whether missing values are suppressed or zeroes, we fill in missing industries where possible. To do so, we sum employment by industry NAICS across all counties in each state and take the difference between this sum and the state-reported employment by industry. We then distribute this difference evenly across all counties with missing data for that industry.

In order to merge employment share data with trade and tariff data, we map HS codes to non-agricultural NAICS 3-digit codes and map HS codes to crops and livestock. To perform this mapping, we searched for all HS codes that contained the name of the crop or livestock type and determined whether the product was sufficiently processed to be considered a non-agricultural product. Since we expect tariffs on minimally processed goods to impact farmers, we map goods with some processing to crop and livestock sectors. For example, an import tariff on beef affects not only meat processing facilities but also feedlot and cow-calf operations in other locations. Generally, we map fresh, frozen, canned, and juiced products to fruit and vegetable production; we map flours, seeds, and roasted cereals to grain production; we map live animals, fresh and frozen meat, raw or tanned skins, and wool (carted and uncarted) to livestock production; and sweetened and unsweetened milks and creams, spreads, and cheeses to dairy livestock production. For illustration, the HS code mapping for tomatoes is recorded in Table 1. We include a table of all HS code mappings to all crop and livestock products in the Appendix 3.

Calculating County Sector Employment Exposure to Domestic and Foreign Import Tariffs

To examine the spatial distribution of tariff changes, we calculate sector j employment exposure to foreign import tariffs for each U.S. county i and for countries $c \in \{MX, CA\}$ as follows:

$$\tau_{it}^{cj} = \frac{\sum_{k \in j} E_{ik}^{1992} RCA_k^{US} \tau_{kt}^{c-US}}{\sum_{k \in j} E_{ik}^{1992} RCA_k^{US}} \tag{5}$$

where E_{ik}^{1992} is employment in industry k in county i in the base year, 1992, RCA_k^{US} is the U.S. Revealed Comparative Advantage in world exports of product k (also from 1992), and τ_{kt}^{c-US} is the tariff that country c imposes on its imports of good k from the U.S. in year t. For $j \in (crop, livestock)$, $E_{ik}^{1992} = L_{ik}^{1992} * E_{ij}^{1992}$ where L_{ik}^{1992} is the share of crop or livestock employment in county i employed in industry k, and E_{ij}^{1992} is 1992 employment provided by the QCEW data in sector j and county i. Therefore, for $j \in (crop, livestock)$, E_{ij}^{1992} cancels out in equation 5 and τ_{it}^{cj} depends only on employment shares, L_{ik}^{1992}. As a result, our measures of exposure to crop and livestock tariffs do not require QCEW labor data. We sum the numerator and denominator over all industries $k \in j$, thus summing over all industries within the specified sector (crop, livestock, or non-agricultural). A notable difference between our measure of tariff exposure and the measure of export exposure described in He (2020) is that our exposure measure does not vary with the share of local employment in national employment for a given sector. The measure described in He (2020) weights local exposure to exports by the local employment in a sector normalized by the product of total local employment across all sectors and the total national employment within the same sector. As a result, conditional on the local share of employment in a given sector, the measure in He (2020) varies depending on whether the local economy has a large share of national employment in the sector. Furthermore, our exposure measure weights tariffs by the exporting country's revealed comparative advantage, which likely has important implications to distinguish tariffs on goods that are highly traded from goods that are rarely traded.

We similarly calculate the U.S. county sector j employment-weighted tariffs on imports from Mexico and Canada as follows:

$$\tau_{it}^{USj} = \frac{\sum_{k \in j} E_{ik}^{1992} RCA_k^c \tau_{kt}^{US-c}}{\sum_{k \in j} E_{ik}^{1992} RCA_k^c} \tag{6}$$

Changes in County Import Tariff Exposure During NAFTA Implementation

Figure 2 shows the county-specific changes in employment-weighted mean exposure to tariffs that Mexico and Canada imposed on imports of U.S. crops and lightly processed related goods and changes in tariffs that the U.S. imposed on crop imports from Mexico and Canada. There were large reductions in average crop employment exposure to import tariffs imposed by Mexico across many rural U.S. counties (see Appendix Figure C.1 for a map of U.S. counties by rural/urban status). Numerous metro areas were also exposed to large changes in Mexican import tariffs, especially those located in areas that produce lots of specialty crops like fruits, vegetables, and tobacco (for example, southern California and parts of the Northeast; see Figure E.2). Reductions in exposure to Canadian import tariffs were relatively small in magnitude. A few regions that mostly specialize in vegetable production were exposed to relatively large declines in U.S. tariffs on crop imports from Mexico.

Figure 3 shows the county-specific changes in employment-weighted mean tariffs that Mexico and Canada imposed on imports of U.S. livestock and animal products and that the U.S. imposed on imports of livestock and animal products from Mexico and Canada.

Again, the largest change in exposure comes from decreases in Mexican import tariffs on U.S. products. Major hog- and poultry-producing counties were exposed to relatively large declines in Mexican import tariffs on U.S. livestock (see Appendix Figure A.2). Dairy producing counties were largely exposed to decreases in U.S. tariffs on imports of livestock and animal products from Mexico and to a lesser extent from Canada. Exposure to changes in Canadian import tariffs on U.S. livestock was relatively small throughout the U.S.

Figure 4 shows the county-specific changes in employment-weighted mean exposure to tariffs that Mexico and Canada imposed on imports of U.S. non-agricultural goods and employment-weighted tariffs that the U.S. imposed on non-agricultural imports from Mexico and Canada. Exposure to changes in Mexican import tariffs on U.S. non-agricultural goods is widespread, though there is some spatial variation. Previous literature has focused on changes in employment exposure to changes in U.S. tariffs on imports from Mexico rather than exposure to declines in Mexican import tariffs on U.S. non-agricultural goods (Hakobyan and McLaren, 2016). However, workers in non-agricultural industries potentially benefited from improved access to export markets.

To examine how labor exposure to tariff changes relates to the locations of specific crop and livestock industries, we map shares of county crop and livestock employment by crop and livestock type in Appendix Figures E.1 to E.4. We find that counties where crop workers were exposed to the largest changes in tariffs during NAFTA were counties that specialized in the production of fruits, vegetables, and tobacco. Although the U.S. is a major exporter of field crops like corn, soybeans, and wheat, the tariff changes for these crops was relatively smaller than for many of the specialty crops, and we find that counties with large acreage of field crops were exposed to relatively small changes in crop tariffs. Changes in average tariff rates by crop are included in Appendix Figures E.5 and E.6.

Labor Sector Exposure to Tariff Changes as a Share of Total County Employment

Our main findings show that the agricultural workforce was exposed to relatively large changes in tariffs during NAFTA. While the agricultural sector witnessed large decreases in Mexican import tariffs, to better understand the labor market impacts of NAFTA, it is important to take into consideration what share of total employment by county is employed in crop and livestock sectors. To see employment exposure as a share of total employment in the county, we recreate the main results weighting tariff exposure by industry shares of total employment. We calculate sector j employment exposure to foreign import tariffs for each U.S. county i and for country $c \in \{MX, CA\}$ as follows:

$$\tau_{it}^{cj} = \frac{\sum_{k \in j} E_{ik}^{1992} RCA_k^{US} \tau_{kt}^{c-US}}{\sum_k E_{ik}^{1992} RCA_k^{US}} \tag{7}$$

where the denominator is summed over all industries across all three sectors. We calculate E_{ik}^{1992} for the crop sector by multiplying our derived crop labor hour shares in county i, L_{ik}^{1992}, by total crop employment in the QCEW, where total crop employment is employment classified under NAICS 111 (Crop Production), NAICS 1151 (Support Activities for Crop Production including FLCs and Crew Leaders), NAICS 311 (food manufacturing) excluding NAICS 3116 (Animal Slaughtering and Processing) and 3117 (Seafood Product Preparation and Packaging), and NAICS 312 (Beverage and Tobacco Product Manufacturing). For livestock, we calculate E_{ik}^{1992} by multiplying the livestock value share for each livestock type in the 1992 Agricultural Census by QCEW employment summed across NAICS 112 (Animal Production and Aquaculture), NAICS 1152 (Support Activities for Animal Production), NAICS 3116, and NAICS 3117. For the non-agricultural sector, as in our main analysis, we use employment summed across all 3-digit NAICS excluding NAICS 111, 1151, 311, 312, 112, and 1152.

We map crop, livestock, and non-agricultural employment exposure to tariff changes weighted by share of total employment in Figures 5, 6, and 7.[9] Crop employment is a substantial share of total employment in very rural counties and counties that specialize in the production of labor-intensive fruits and vegetables, so we still observe that labor exposure to changes in crop tariffs weighted by share of total employment was large (a change of more than 15 percentage points in the tariff rate for some counties). Counties exposed to large crop tariff changes after weighting by share of total employment were primarily located in California, Washington, and Florida, but there was noticeable exposure to declines in Mexican import tariffs on U.S. crops in counties dispersed across the country. These highly exposed counties mostly produce labor-intensive crops, such as fruits and vegetables. Livestock tends to be less labor-intensive on average and constitutes a more substantial share of employment only in very rural counties, so we observe few counties where the change in livestock tariff rates weighted by industry share of total employment in the county was larger than 3 percent. Non-agricultural labor exposure to changes in Mexican import tariffs on U.S. products are more concentrated in the Eastern U.S. once we scale using non-agricultural labor's share of total county employment.

Discussion and Policy Implications

Labor exposure to agricultural and non-agricultural tariff changes from NAFTA has several important lessons for policy moving forward. First, our work contributes directly to current U.S. trade policy discussions. Politicians from both major U.S. political parties have proposed increased import tariffs to protect domestic industries. Our work demonstrates that rising barriers to trade likely have differential effects across regions of the U.S. and sectors of the economy. While Hakobyan and McLaren (2016) focus on the domestic impacts of lowering U.S. import tariffs, our work shows that U.S. worker exposure to decreases in foreign import tariffs on U.S. export products differed substantially across sectors of work and geographic location. Trade theory would predict that increases in U.S.

[9] We also present results for changes in tariffs on food, beverage, and tobacco manufacturing sectors in Appendix Figure D.1. Small exposure to tariff changes suggests that our results are not driven by our choice to map lightly processed foods into crop and livestock sectors.

access to foreign export markets should increase demand for labor, thus putting upward pressure on employment and wages, even as decreases in U.S. tariffs on imports during NAFTA implementation put downward pressure on employment and wages. Our findings suggest that the increased worker exposure to foreign trade policy was substantial, and further investigation is needed to determine to what extent the reduction in tariffs that Mexico and Canada imposed on the U.S. affected U.S. employment and wages by sector and geographic location. The lessons from this and related work may be particularly important for predicting the impacts on labor of implementing higher import tariffs in the U.S. if other countries respond by also increasing protection.

Our work also has implications for agricultural labor specifically, which has been largely overlooked in previous literature. In regions with high employment in agriculture, tariff changes in other countries may have large impacts since the U.S. is a major exporter of agricultural goods. For example, producers in some regions of the U.S. were negatively impacted by Chinese tariff increases on U.S. agricultural products (e.g., soybeans) in 2018 (Janzen and Hendricks, 2020). The federal government recognized the losses these tariffs imposed on the agricultural sector, but compensation payments (e.g., through the Market Facilitation Program) went to farm operators and may not reach agricultural workers who would also be impacted by the change in tariffs. Effects on agricultural labor fall on relatively poor households. This is evidenced by rising poverty rates as farm employment rose within U.S. counties between 1980 and 1990 (Martin and Taylor, 2003).

Agricultural worker exposure to foreign tariffs documented in this paper also suggests that there may be an underappreciated linkage between trade policy and immigration policy. Higher foreign tariffs on U.S. agricultural products may reduce the demand for agricultural labor and change the demand for immigrant workers across sectors, which could have important implications for rural economic outcomes, including poverty (Martin and Taylor, 2003). Future work is warranted to better understand how trade policy changes the sector and location in which individuals work. Further exploration could also test for crop-specific responses to foreign tariffs. The potential to focus on workers instead of counties highlights many interesting questions regarding the distributional effects of changes in trade policy exposure.

Conclusion

While the field of economics consistently demonstrates that workers are not perfectly mobile across industries or geographic space (Autor, Dorn, and Hanson, 2013; Autor et al., 2014; Dix-Carneiro and Kovak, 2015, 2017; Hakobyan and McLaren, 2016; Topalova, 2007, 2010), there has been little research on U.S. agricultural worker exposure to trade liberalization or protectionism. This can be especially important in rural communities with a large agricultural share of employment. Although the share of the U.S. population employed in agriculture and related industries is relatively small (10.4% of U.S. employment in 2022 (USDA Economic Research Service, 2023)), agriculture remains an important part of many rural communities. We find that changes in foreign tariffs on U.S. products were large relative to changes in U.S. tariffs on imports. This suggests that research should consider both exposure to tariffs on imports that increase competition in domestic markets and exposure to import tariffs in export markets that affect competitiveness in foreign markets.

Finally, we show that employment-weighted exposure to reduced Mexican import tariffs on U.S. crop and livestock sectors was particularly large in several regions of the country. Given the relatively large declines in foreign import tariffs that U.S. crop and livestock workers were exposed to, NAFTA might have benefited many industries and workers in nearby locations if there were substantial spillovers. This mechanism remains underexplored in the literature that has focused primarily on losses in non-agricultural employment protection from U.S. tariff reductions on imports and merits further empirical investigation.

It may also be the case that individual workers are part of households with labor that is diversified across multiple sectors. Off-farm labor has been shown to have a wide range of effects on farm household outcomes in the U.S. (e.g., Mishra and Chang (2012)). Working off farm can mitigate agricultural risk (Bubela, 2016). In terms of how this affects our measure of labor exposure to tariffs, our estimate is based on labor hours by crop and sector and does not distinguish between labor within the same or different households. It also does not distinguish between management and hired labor. If a household member works in both crop farming and non-agricultural sectors, the labor that household provides could be counted in both sectors. In response to a tariff change, households could reallocate labor from industries facing relatively high tariffs to industries with lower tariffs. Further, diversified households may be exposed differently from labor (e.g., with some members benefiting from tariffs and others benefiting from more international trade). This suggests an avenue for future work to quantify how households rather than employment sectors are exposed to tariff changes.

There is much yet to investigate regarding the effects of agricultural trade and tariff changes on employment and wages. This paper develops crop- and livestock-specific employment weights and calls for future work to explore changes in tariff exposure to NAFTA and other trade policies. Employment weights can be used in analyses investigating a wide range of impacts on agricultural labor, ranging from specific crop mechanization to trade wars and climate change. Future work can examine the relative strengths and weaknesses of our method and using QCEW data to measure exposure to trade policies (Autor et al., 2024). Overall, measuring sector-specific employment exposure to trade policy enables timely future investigation connecting crop- and livestock-specific natural and market-driven shocks to employment and wage outcomes across U.S. counties.

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Figure 1: Adjusted mean import tariffs weighted by the exporting trade partner's Revealed Comparative Advantage in 1992

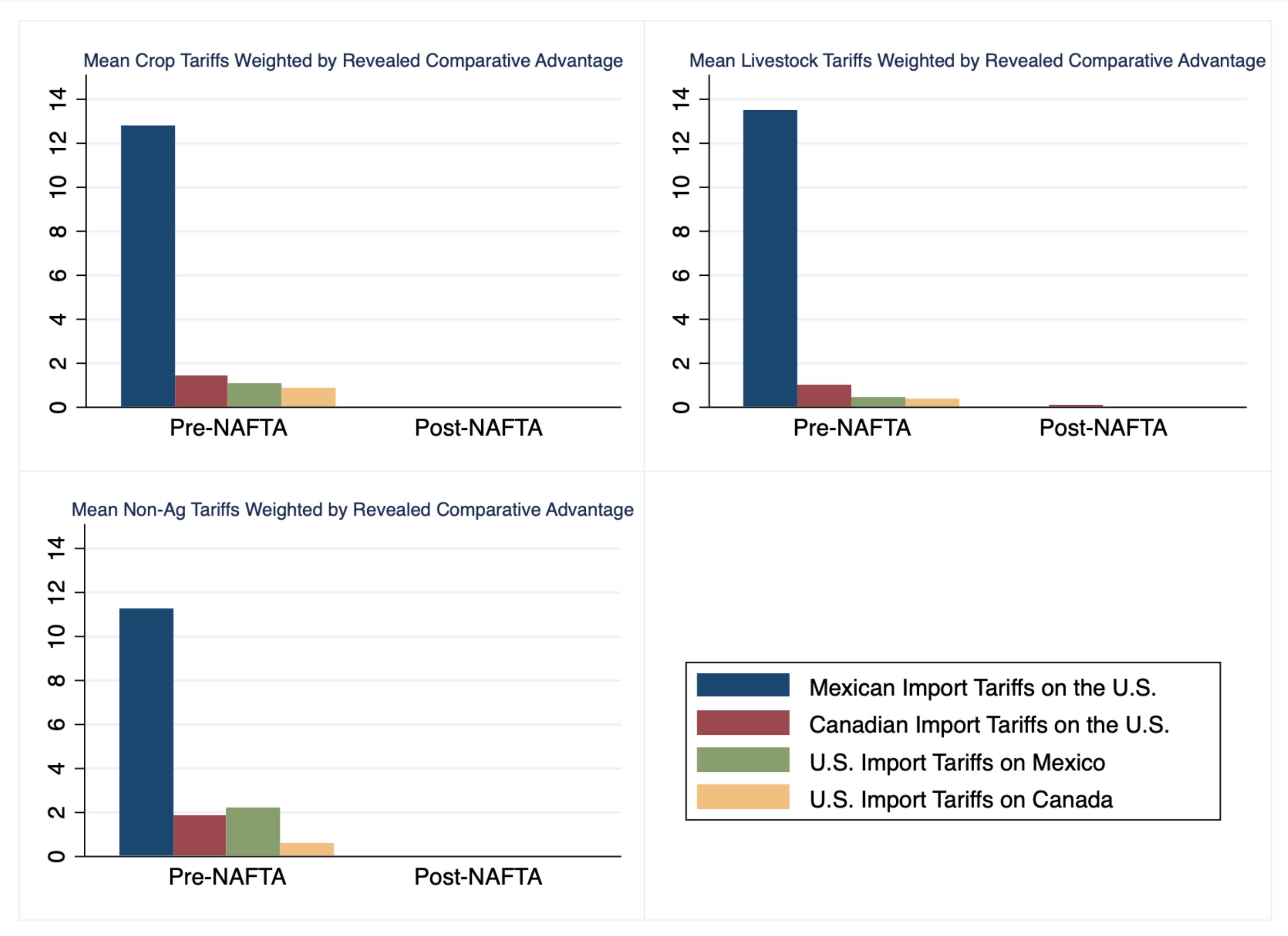


Figure 2: Changes in county-level employment-weighted mean import tariffs on crops traded in North America

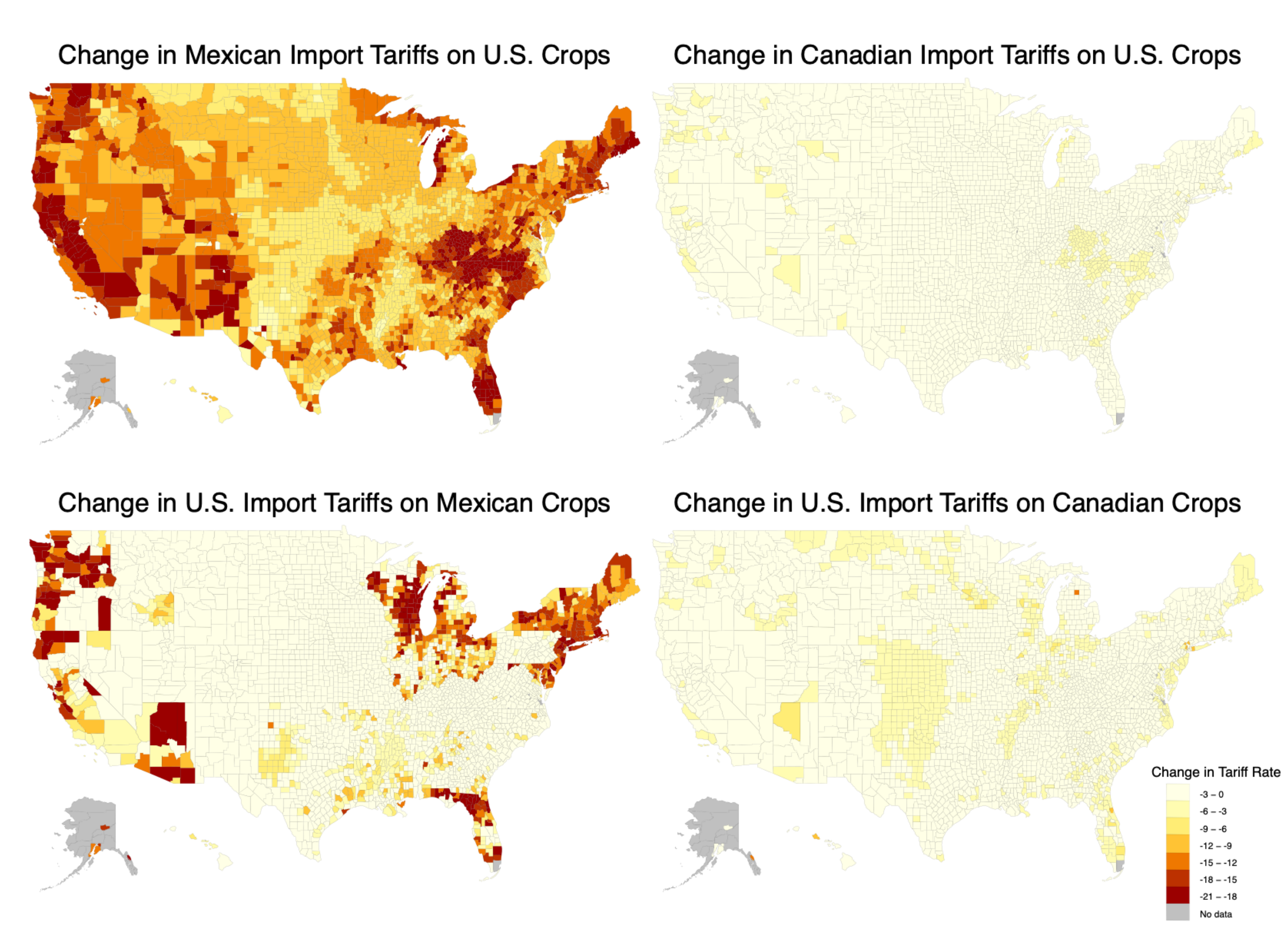
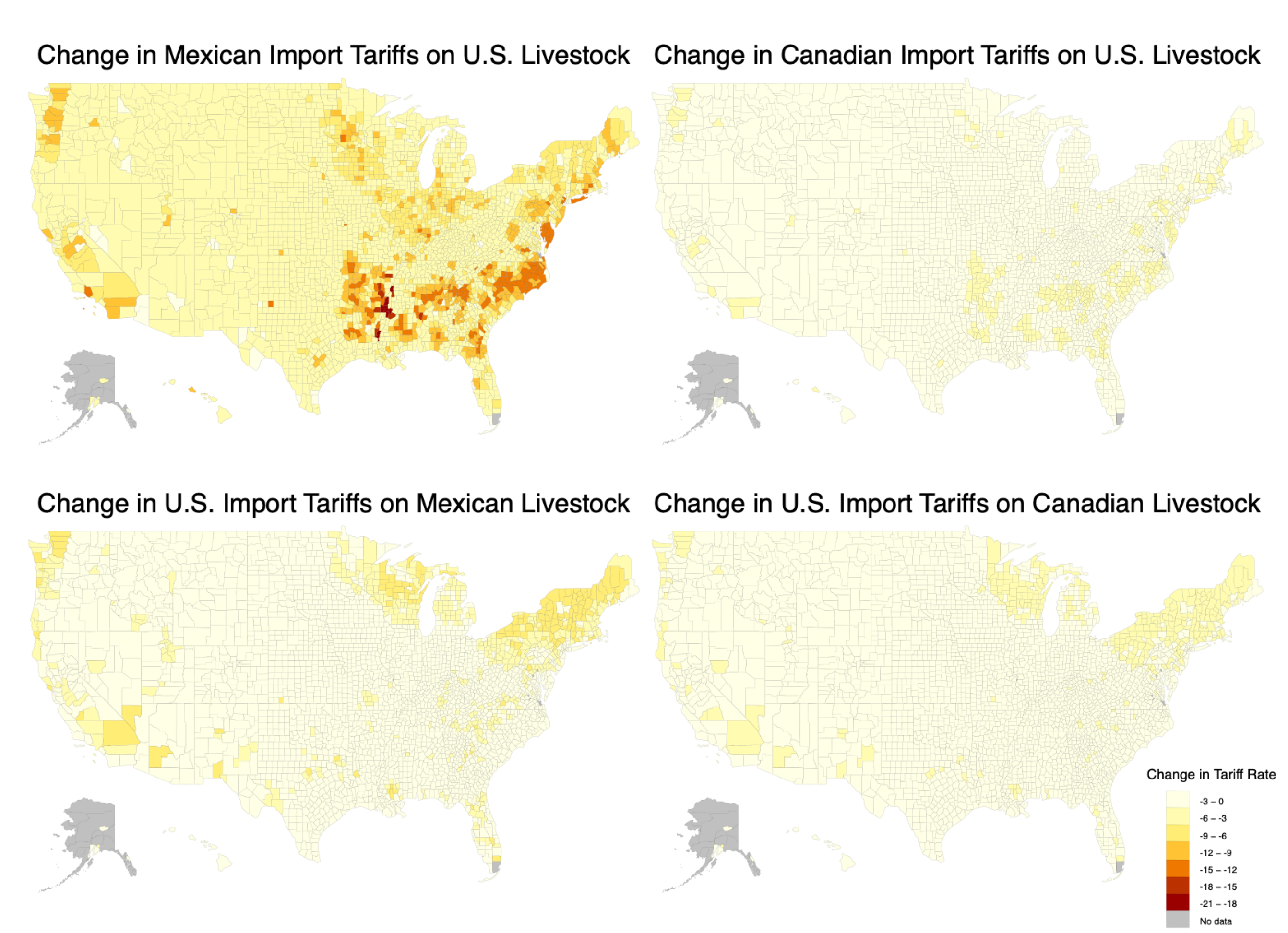


Figure 3: Changes in county-level employment-weighted mean import tariffs on livestock and animal products traded in North America



Note: Livestock and animal products include cattle, dairy, hogs, sheep, poultry, mink, catfish, trout, bass, crawfish, and other fish or aquaculture.

Figure 4: Changes in county employment-weighted mean import tariffs on non-agricultural products traded in North America

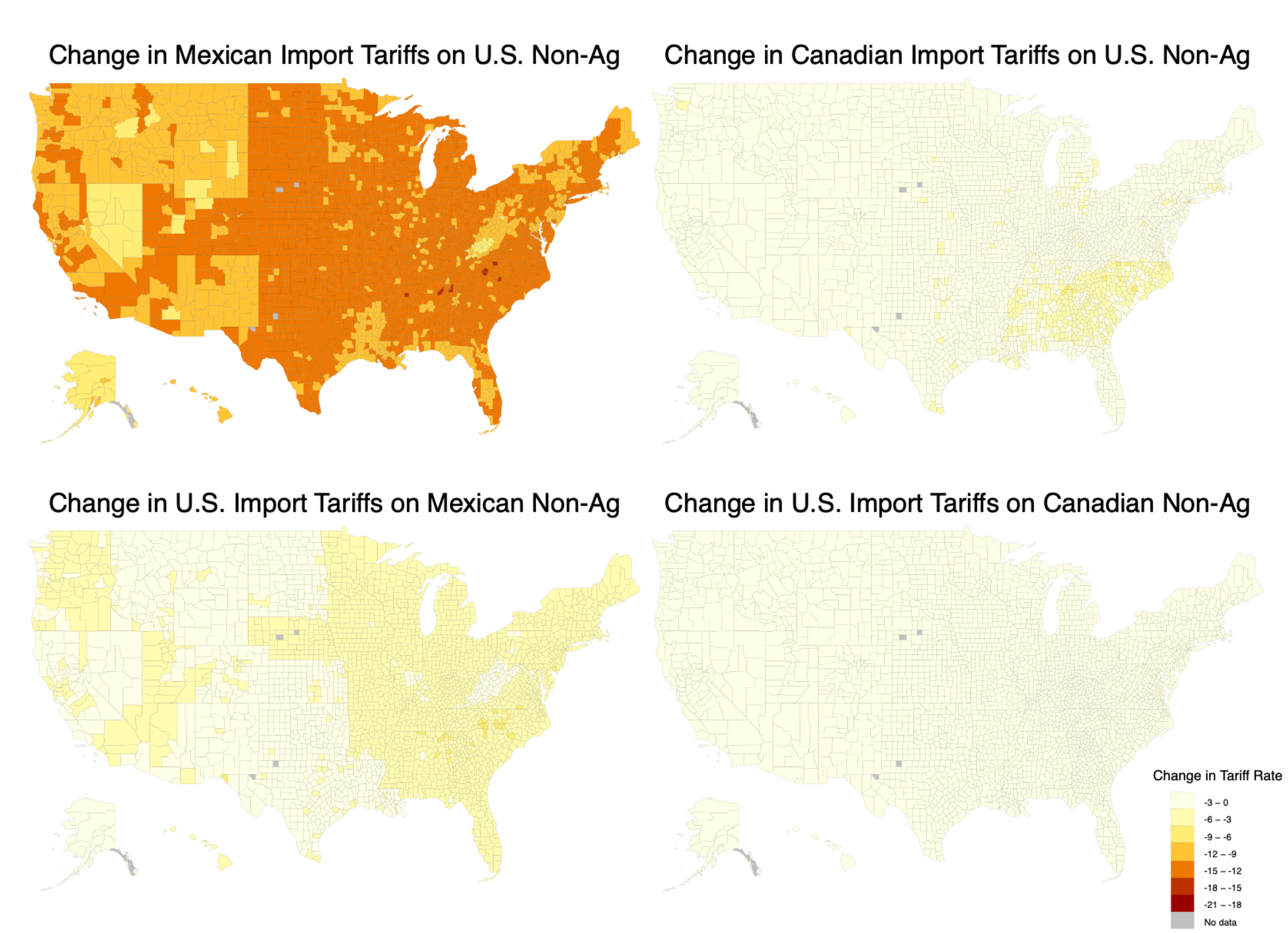


Figure 5: Changes in employment exposure to crop tariffs (percentages): Measuring employment exposure as crop share of total employment in the county

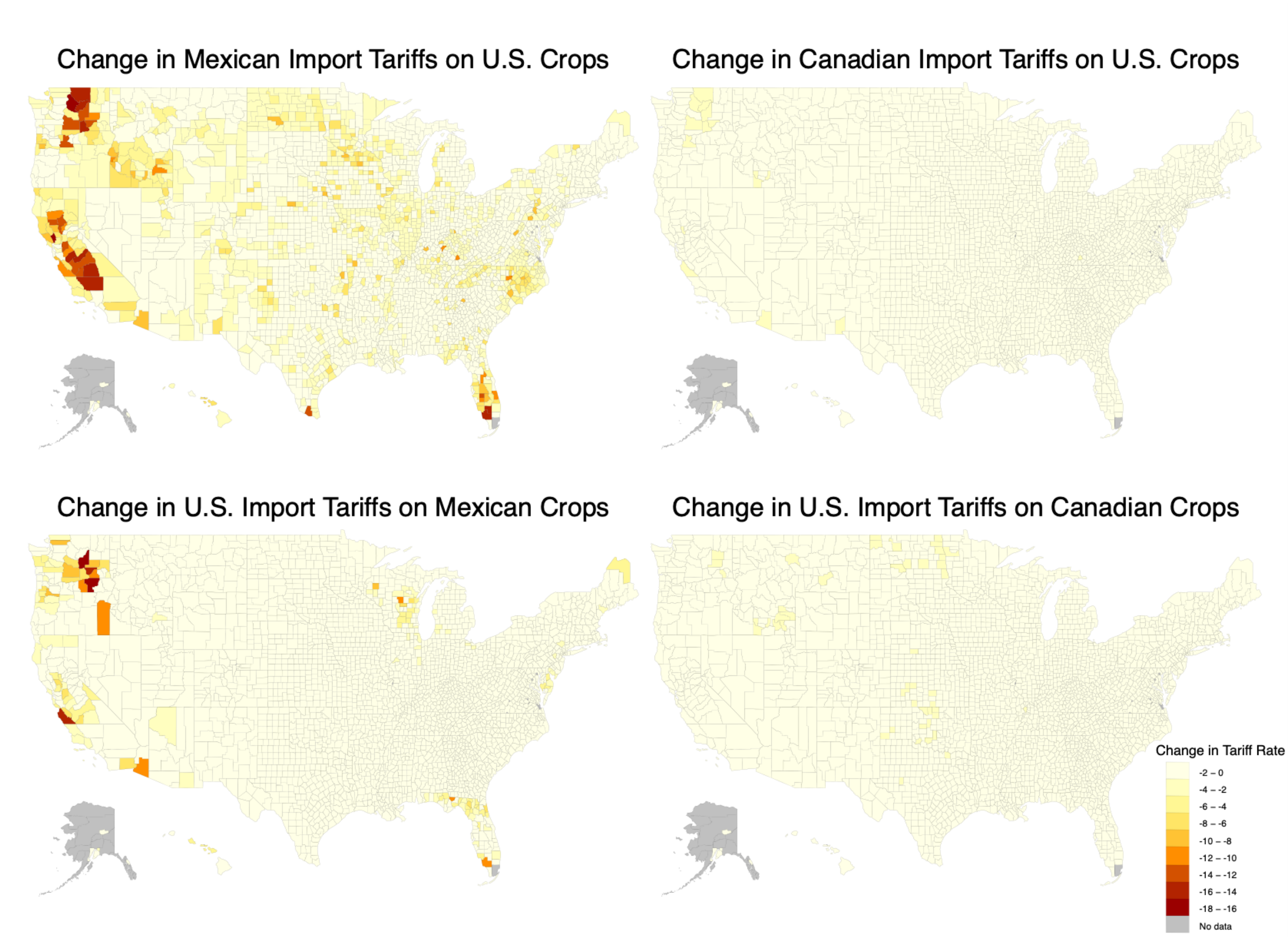


Figure 6: Changes in employment exposure to livestock tariffs (percentages): Measuring employment exposure as livestock share of total employment in the county

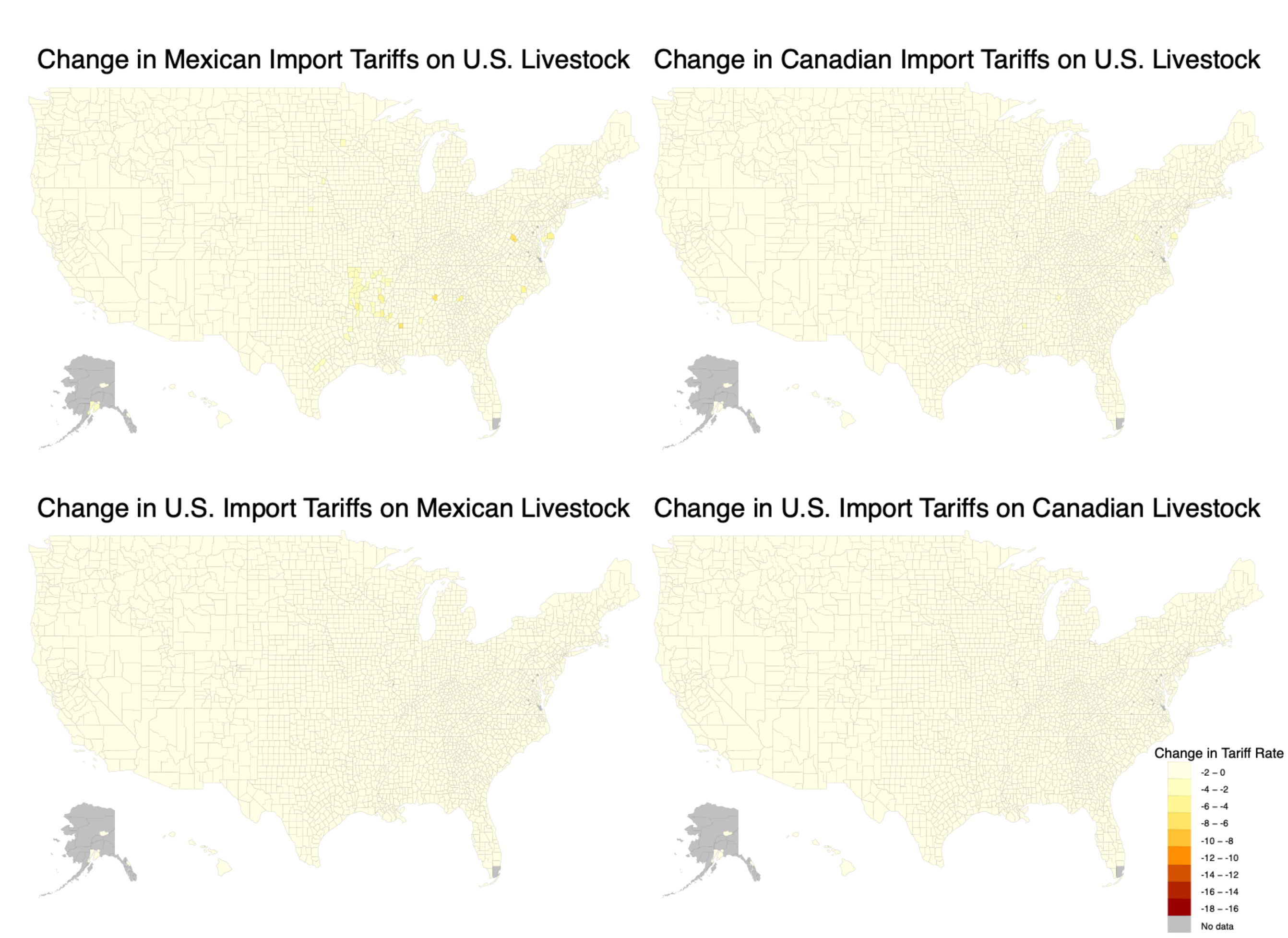


Figure 7: Changes in employment exposure to non-agricultural tariffs (percentages): Measuring employment exposure as non-agricultural share of total employment in the county

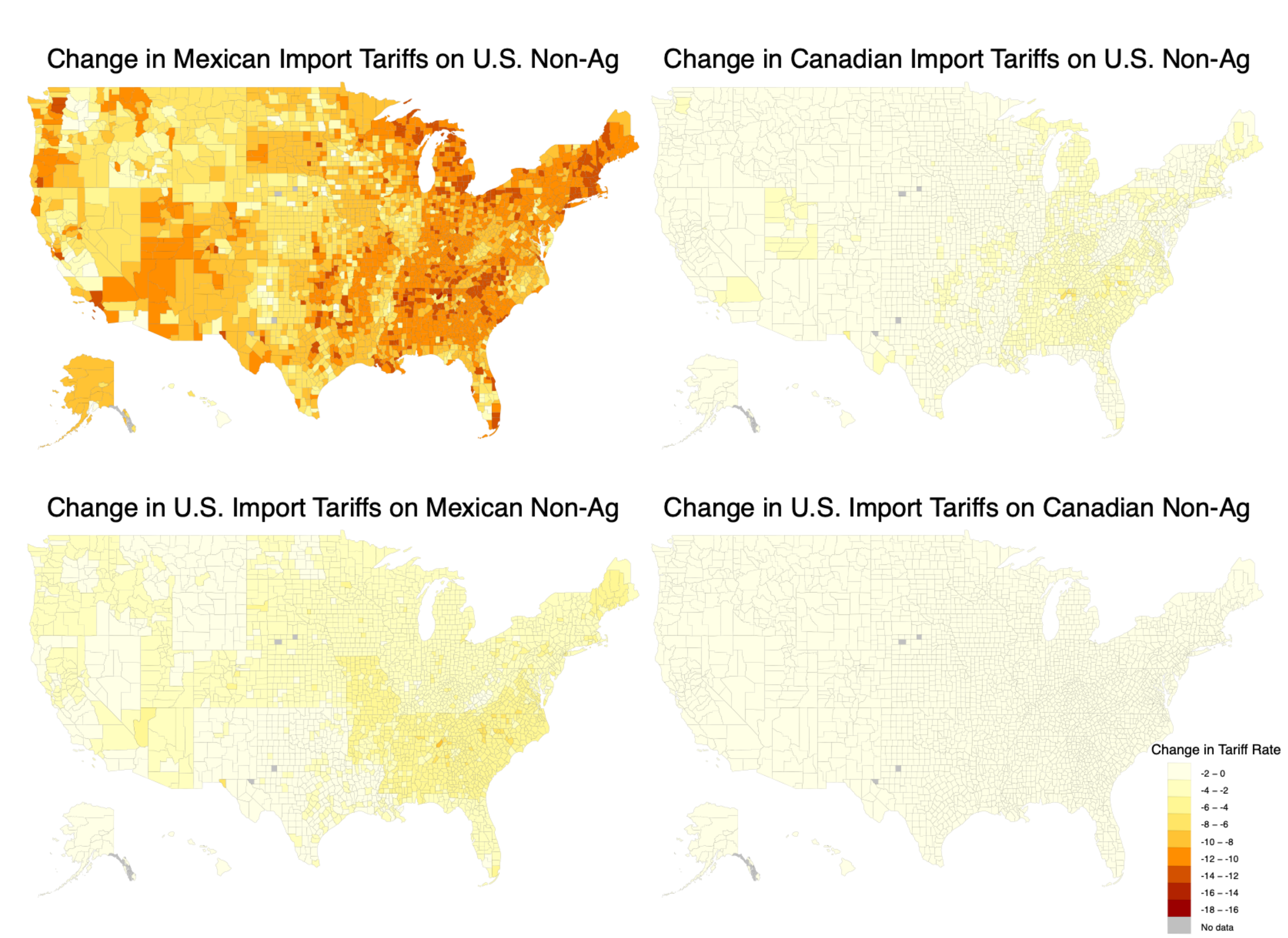


Table 1: Example of Harmonized System mapping: Tomatoes

HS Code	**Definition**
70200	Vegetables; Tomatoes, fresh or chilled
200210	Vegetable preparations; tomatoes, whole or in pieces, prepared or preserved otherwise than by vinegar or acetic acid
200290	Vegetable preparations; tomatoes (other than whole or in pieces) prepared or preserved otherwise than by vinegar or acetic acid
200950	Juice; tomato, unfermented, not containing added spirit, whether or not containing added sugar or other sweetening matter
210320	Sauces; tomato ketchup and other tomato sauces