Exporting out of Agriculture: The Impact of WTO Accession on Structural Transformation in China*

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September 10, 2018

Abstract

This paper analyzes the effect of China's accession to the World Trade Organization in 2001 on structural transformation at the local level, exploiting cross-sectional variation in tariff uncertainty faced by local economies pre-2001. Using a new panel of approximately 2,000 Chinese counties observed from 1996 to 2013, we find that counties more exposed to the reduction in tariff uncertainty post-accession are characterized by increased exports and foreign direct investment, shrinking agricultural sectors, expanding secondary sectors, and higher total and per capita GDP. Moreover, when labor substitutes from non-agricultural to agricultural production in counties exposed to positive trade shocks, agricultural output declines, a pattern inconsistent with the predictions of the surplus labor hypothesis, and consistent with other evidence suggesting that stocks of excess labor in Chinese rural areas have been depleted. These findings are robust to a range of alternate specifications, and to controlling for other contemporaneous reforms.

JEL Classification: F14, F16, O14, O19

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*For their comments and suggestions, we would like to thank seminar participants at Northeastern University, the Office of the Chief Economist at the State Department, Boston University, the University of California - Santa Barbara, the Stockholm Institute of Transitional Economics, and the Asian Meeting of the Econometric Society. We would also like to thank Daron Acemoglu, David Autor, Brian Kovak, Brian McCaig, Maggie McMillan, Mindy Marks, Daniele Paserman, Nina Pavcnik, Ivan Petkov, Dani Rodrik, and Xiaobo Zhang for detailed comments. All errors are, of course, our own.

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1 Introduction

Over the past two and a half decades, China has experienced a process of remarkable structural transformation accompanied by rapid economic growth. The share of total employment in the agricultural sector fell from 60% in 1990 to 28% in 2015, and this sectoral shift was matched by unprecedented growth in non-agricultural output, as evident in Figure 1. At the same time, China also experienced a rapid rise in manufacturing exports, increasing from 2% to 19% of global manufacturing exports. This transformation broadly coincided with China's accession to the World Trade Organization in 2001.

China's record of growth has generated a robust debate about its causes. While some analysts argue that trade liberalization stimulated economic growth (Sun and Heshmati, 2010; McMillan and Rodrik, 2011), there is relatively little direct evidence of this relationship. More generally, in a comprehensive review of the recent literature, Goldberg and Pavcnik (2016) conclude that there is only limited empirical evidence of the relationship between trade policy and growth, and further work is required to flesh out this relationship. In addition, a robust literature argues that in fact internal policy reforms, including the reform of state-owned enterprises and the creation of Special Economic Zones, were more critical in enabling China to increase productivity and realize its comparative advantage in manufacturing (Song et al., 2011; Autor et al., 2016). Other analysts argue that the reduction of domestic tariffs had a large positive effect on the manufacturing sector (Manova and Zhang, 2012; Brandt et al., 2015), but there is almost no empirical evidence about the effects of trade liberalization on other economic sectors or on the process of structural transformation writ large.

At the same time, a growing literature has analyzed the determinants of structural change in the developing world, primarily focusing on "push factors", or positive shocks to agricultural productivity.[1] There is much less evidence around the effect of trade liberalization, arguably among the most important "pull factors" that can stimulate the substitution of productive factors out of agriculture.[2] Given the growing evidence that productivity is much lower in agricultural compared to non-agricultural production in developing economies, this substitution has important macroeconomic implications (Gollin

[1] More specifically, Foster and Rosenzweig (2004) estimate the impact of shocks to the returns to agriculture in India induced by Green Revolution technology, and find that industrial growth is fastest in areas where agricultural growth is lagging. Hornbeck and Keskin (2015) find no evidence that positive agricultural growth generated by the construction of an aquifer in the U.S. generates non-agricultural growth, while Bustos et al. (2015) present evidence that technological innovations in the soybean sector in Brazil generate industrial growth only when they are labor-saving.

[2] An expanding literature examines the importance of international trade in explaining structural change by using open-economy models that incorporate nonhomothetic preferences, skill-biased technical change, aggregate trade imbalances, and input-output linkages (Matsuyama, 2009; Uy et al., 2013; Cravino and Sotelo, 2017; Reyes-Heroles et al., 2018; Lewis et al., 2018; Matsuyama, 2018). Section 1.1 provides a detailed discussion.

et al., 2014; McMillan et al., 2014; Matsuyama, 2018). Analyzing trade liberalization in China — the focus of this study — represents a valuable opportunity to analyze the effects of an exogenous "pull" shock on structural transformation.

In this paper, we provide new evidence about the effects of China's WTO accession on structural change and growth at the local level, analyzing a newly assembled panel of approximately 2,000 counties observed between 1996 and 2013. China's WTO membership significantly reduced uncertainty about U.S. trade policy vis-a-vis China, boosting bilateral trade and generating a substantial increase in both total Chinese exports to the U.S. and total exports, evident in Figure 2 (Handley and Limão, 2017; Pierce and Schott, 2016b). At the same time, aggregate shifts in labor allocation patterns begin to emerge: primary employment, previously roughly stagnant at the national level, began to contract at a rate of 3.5 percent annually post-2002, and the annual rate of growth of secondary employment nearly tripled. Given this evidence of meaningful macro-level shifts, we utilize an identification strategy that allows us to examine the effects of cross-sectionally varying shocks generated by the reduction in uncertainty, and present evidence that this shock led to significant growth in exports and foreign direct investment in more exposed regions. This in turn stimulates a reallocation of productive factors from agriculture into manufacturing and services, and a significant increase in county-level output.

More specifically, China's Most Favored Nation (MFN) status in the U.S. required annual renewal by Congress prior to 2002, a process entailing considerable risk; if the renewal had failed, Chinese exports would have been subject to the much higher rates reserved for non-market economies.[3] The U.S. permanently granted Normal Trade Relations (NTR) status—a U.S. term for MFN status—to China in October 2000, tied to its WTO membership and effective as of January 1, 2002 (Handley and Limão, 2017). By contrast, the status of Chinese exports in other markets did not change. Our empirical design utilizes variation across industries in the gap between the NTR tariffs permanently granted by the U.S. post–2001 and the non-NTR rates, in conjunction with variation across counties in the composition of employment by industry reported in the 1990 census.[4] The interaction of these two sources of variation generates a county-level variable capturing the exposure of local industries to tariff uncertainty pre-2001. If this uncertainty is a significant barrier to exporting, these more exposed counties should experience more rapid export expansion and substitution into the secondary sector post–2001.

While previous studies have analyzed the impact of trade liberalization on the manu-

[3]For example, in 2000, the average U.S. MFN tariff was 4%, but China would have faced an average non-MFN tariff of 31% had its MFN status been revoked.

[4]Pierce and Schott (2016b) and Handley and Limão (2017) use this empirical strategy to examine the effects of permanent NTR status on U.S. manufacturing employment and consumer prices using industry-level data.

facturing sector using firm-level or customs data, we preferentially use county-level data in order to analyze patterns of factor substitution across sectors and identify the effects of China's WTO accession on the extensive, growth margin, in addition to the intensive margin. The county is an important unit of analysis in the literature on the Chinese economy, corresponding to a local labor market with defined fiscal and economic policies (Chen and Kung, 2016; Zhang, 2006). In addition, we are able to exploit this novel dataset to trace the effects not only in the short term, but for approximately 15 years post-accession. Relatively few studies have been able to trace long-term effects of trade liberalization, and identify if these effects persist.

Our primary results suggest that counties more exposed to tariff uncertainty prior to 2001 experienced significantly faster growth in exports, greater expansion in the secondary sector, greater contraction in the primary sector, and more rapid increases in total and per capita GDP following WTO accession, conditional on county and province-year fixed effects. Comparing a county at the median level of uncertainty ex ante to a county characterized by the minimum level of uncertainty, the more exposed county shows evidence of an increase in exports of around .15 log points, and increases in secondary, total and per capita county GDP of around .05 log points. This export-driven expansion also has ancillary effects on other sectors: productive factors shift out of agriculture, agricultural production declines, tertiary output expands, and there is some evidence of in-migration. Using firm-level data, we also document that more exposed regions experience an increase in value added per worker in the manufacturing sector, and a corresponding rise in the average wage. The observed effects are concentrated in counties with a higher initial concentration of capital-intensive industries and industries that initially export a higher proportion of their output to the U.S., as well as counties more proximate to major ports.

Importantly, the evidence of contraction in agricultural output in counties more exposed to positive export shocks inducing factor substitution into non-agricultural production is inconsistent with the predictions of a classic surplus labor model. Rather, this pattern is consistent with other recent work arguing that stocks of surplus labor in rural areas have largely been depleted as China reaches the Lewis turning point (Zhang et al., 2011; Kwan et al., 2018). We present additional evidence that the decline in agricultural output is accelerating as labor continues to substitute into new sectors, and that this decline is also larger in areas that have experienced an agglomeration of positive shocks to export-oriented production in multiple counties within a prefecture.

Moreover, the magnitude of the implied effects is significant; our findings suggest that reduced trade uncertainty accounted for approximately 10% of total output growth during this period, and that substitution of productive factors from agricultural to non-agricultural production generated an increase of around 10% in aggregate productivity.[5] This evidence is consistent with the stylized fact that structural transformation has been growth-enhancing in Asia, though not necessarily in other parts of the developing world (McMillan and Rodrik, 2011). Our paper is the first to estimate the causal effects of enhanced access to U.S. export markets on structural transformation and growth at the local level in China.[6] This paper is also one of the first to provide evidence on the employment and GDP effects of enhanced access to advanced country markets in a developing country context.

In addition, our results are consistent with a theoretical literature that predicts a reallocation of workers from less income-elastic sectors such as agricultural production into more income-elastic sectors including manufacturing in response to increased access to export markets. For example, open-economy models with nonhomothetic preferences predict that lower trade costs result in productivity gains and higher income growth, shifting expenditure toward income-elastic sectors (Matsuyama, 2009; Uy et al., 2013; Herrendorf et al., 2014; Matsuyama, 2018). More generally, open economy models of structural change predict that declining trade costs can induce labor reallocations across sectors (Uy et al., 2013; Cravino and Sotelo, 2017; Reyes-Heroles et al., 2018), but previous empirical work has generally found limited evidence of intersectoral labor reallocation in response to trade shocks, particularly in the short run.[7] Our empirical specification allows us to capture the factor reallocation effects generated by declining implied trade costs at the level of local labor markets over a relatively long period of time.

We also provide extensive evidence of the robustness of our results. The empirical specifications all control for variation in U.S. tariff levels during this period, as well as a range of other trade reforms implemented by both China and the U.S., including the elimination of export licensing requirements, the reduction in barriers to foreign investment, and the expiration of the Multi-Fiber Arrangement. In general, variation in the level of tariffs imposed by the U.S. and other trading partners is small in magnitude relative to the potential increase in tariffs risked if China's NTR status had been revoked prior to WTO accession. While we show that this variation in levels has some effect on economic outcomes, the effects of tariff uncertainty prove to be significantly larger.

Further robustness checks demonstrate that there is no evidence of any significantly

[5] As we document in Section 5.3, the productivity differences across sectors are substantial: value added per worker in the secondary sector is approximately 6.5 times value added per worker in the primary sector.

[6] In this context, the primary sector includes agriculture and agricultural extensions, the secondary sector includes manufacturing and mining, and the tertiary sector includes services.

[7] These studies include Revenga (1997), Currie and Harrison (1997), Feliciano (2001), Attanasio et al. (2004), Wacziarg and Wallack (2004), and Topalova (2010). However, examining a longer time period at the level of local labor markets, Dix-Carneiro and Kovak (2017) find that trade liberalization in Brazil induced a shift of workers from tradable into nontradable employment.

different trends when comparing counties characterized by different NTR gaps prior to China's WTO accession; the gap in their economic trajectories emerges only post–2001, consistent with the hypothesis that the key channel is more secure access to the U.S. market. Similarly, the key results are consistent when differential trends for counties characterized by different initial economic conditions are included, including differential trends for counties that are initially more concentrated in non-agricultural production. Finally, we conduct a placebo test that suggests that the cross-sectional variation in the NTR gap is associated only with increased exports to the U.S., and does not predict any increase in exports to other major export markets.

1.1 Related literature

This paper contributes to several related literatures. First, a number of studies have sought to identify the impact of trade liberalization on the Chinese manufacturing sector, focusing on industries or firms as the unit of analysis, and primarily analyzing variation in tariff levels. Although our findings complement these studies, our paper differs significantly in its focus on structural transformation and county-level growth, as well as the channels through which the reduction of trade policy uncertainty may affect these outcomes. In the existing literature, Brandt et al. (2015) demonstrate that reduced Chinese import tariffs following WTO accession led to significant gains in manufacturing productivity, and Brandt and Morrow (2014) and Manova and Zhang (2012) show that reduced tariffs have also resulted in increased access to imported inputs. Bai et al. (2017) and Khandelwal et al. (2013a) analyze the impact of the removal of export restrictions and MFA quotas on export growth and manufacturing productivity at the firm level, respectively. Recent work has also found that the diminished trade policy uncertainty following China's WTO accession has boosted patent applications (Liu and Ma, 2016) and stimulated entry into export-oriented production (Feng et al., 2017).[8]

Second, an extensive literature analyzes the effects of increased manufacturing exports from China on manufacturing in developed countries, as summarized in the overview provided by Autor et al. (2016); our paper contributes to this literature by documenting the effects of this reduction in trade uncertainty in China. Autor et al. (2013) and Acemoglu et al. (2016) exploit variation across metropolitan statistical areas in their exposure to Chinese competition. The identification strategy employed in this paper is closely related to Pierce and Schott (2016b), who use industry data to analyze the effects

[8]A smaller literature has analyzed structural transformation in China in a broader context. Brandt et al. (2013) analyze shifts in factor market distortions in the non-agricultural economy. Marden (2015) provides evidence that agricultural growth in the early reform period is associated with significantly faster growth in non-agricultural output. Leight (2016) analyzes the effect of Bartik-style labor demand shocks on local industrialization in China.

of diminished trade policy uncertainty on U.S. manufacturing employment.[9] Similarly, Handley and Limão (2017) estimate the impact of reduced trade policy uncertainty on U.S. consumer prices.

Third, our study contributes to the literature on trade liberalization in developing countries by presenting evidence on the employment and GDP effects of the elimination of trade policy uncertainty in China. A number of papers have analyzed the effects of domestic tariff cuts on regional labor market outcomes in Brazil (Chiquiar, 2008; Kovak, 2013; Dix-Carneiro and Kovak, 2015), but existing studies evaluating the effects of expanded access to developed country markets largely focus on Vietnam. Exploiting shocks generated by a bilateral trade agreement, McCaig (2011) finds that the U.S. tariff cuts reduced poverty in Vietnam, and McCaig and Pavcnik (2014b) and McCaig and Pavcnik (2014a) analyze reallocation of labor between household businesses and the formal sector. Another recent paper analyzes trade shocks linked to China's WTO accession on internal migration, but it utilizes only prefecture-level data (Facchini et al., 2016).

More broadly, our paper contributes to a small but growing literature on how international trade and openness affect structural change. Using a two-country model with a continuum of sectors under nonhomothetic preferences, Matsuyama (2018) offers a unifying theoretical framework that shows how reductions in trade costs amplify, instead of reducing, the effects of endogenous domestic demand composition differences as a driver of structural change. In earlier work, Matsuyama (1992, 2009) underscores that closed-economy models are largely inadequate to explain patterns of structural change since they abstract from how international trade shapes these patterns. Using a three-sector, open-economy model, Uy et al. (2013) show that high productivity growth in South Korea's manufacturing sector yielded an enhanced comparative advantage, generating an increase in the manufacturing share of employment; in contrast, a closed-economy model would generate a decline. Cravino and Sotelo (2017) show that structural changed induced by greater manufacturing trade increases the skill premium, particularly in developing countries.[10] Teignier (2018) calibrates a two-sector, neoclassical growth model, finding that

[9]The same authors have also presented evidence regarding the effects of Chinese import competition on voting patterns (Pierce and Schott, 2016a) and mortality (Pierce and Schott, 2016c). Additional research has analyzed the effect of Chinese import competition on manufacturing employment in Norway, Spain, Germany and Brazil (Balsvik et al., 2015; Costa et al., 2016; Dauth et al., 2014, 2017; Donoso et al., 2015).

[10]Recent general equilibrium models have also aimed to explain how lower trade costs induce structural change. Reyes-Heroles et al. (2018) presents a dynamic general equilibrium model of international trade and structural transformation that incorporates two channels—the determination of sectoral net exports and the interaction between comparative advantage and aggregate trade imbalances—in addition to skill-biased technical change and nonhomothetic preferences). Lewis et al. (2018) develop a general equilibrium trade model with nonhomothetic preferences and input-output linkages, which shows that structural change is crucial for estimating the dynamics of trade barriers and ongoing structural change

agricultural imports induced structural change in the United Kingdom even more than South Korea. We contribute to this recently growing literature by empirically demonstrating how enhanced access to advanced country markets has induced structural change and economic growth in China.

The remainder of the paper proceeds as follows. Section 2 provides more background on China's accession to the WTO and a simple conceptual framework. Section 3 describes the data. Section 4 presents the identification strategy and the empirical results. Section 5 presents robustness checks, and Section 6 concludes.

2 Background and conceptual framework

2.1 China's WTO accession

China's accession to the WTO in 2001 was the outcome of a lengthy and extensive negotiation process initiated in 1986. As a member, China both received new trade access benefits and committed to additional, liberalizing domestic reforms. However, both the benefits and the reforms inherent in WTO accession were largely phased in gradually and did not result in any discontinuous jumps in 2001. It is useful to highlight the most important policy changes implemented by China as part of this process, including reduced import tariffs, the relaxation of export licensing rules, and fewer barriers to foreign investment.

First, Chinese import tariffs had already been sharply cut prior to 2001 (from a weighted average of over 45% in 1992 to approximately 13% in 2000). WTO accession entailed further cuts (to approximately 7%), but these shifts were relatively small compared to the pre-accession reforms (Bhattasali et al., 2004). Figure 3a shows the evolution of the average weighted domestic tariff rate over time, calculated using industry-level tariffs and the share of each industry in total Chinese imports as reported in 1996 (the first sample year). Agricultural tariffs remained relatively high (22%) as of 2001 and required further cuts to 17.5% by 2004, with deeper cuts for agricultural products prioritized by the U.S. (e.g., corn). In addition, sanitary and other non-tariff barriers to U.S. exports of citrus, meat and grains were eliminated when China accepted U.S. inspection standards, and American companies were also allowed to freely trade agricultural products within China (Cheong and Yee, 2003).

Second, restrictions on direct exporting were substantial prior to WTO accession, though variable by industry, while firms that were not granted licenses to export directly were required to export via partners. In 2000, slightly more than half of the large firms

implies declining trade openness.

observed in annual surveys of large industrial enterprises were not permitted to export directly, but all firms were allowed to export freely by 2004 (Bai et al., 2017). Third, prior to WTO accession, China had generally implemented relatively attractive policies to draw in foreign investment. However, foreign firms were subject to performance requirements, including criteria related to local content, technology transfers, and investments in research and development. These requirements were eliminated following China's accession to the WTO, facilitating a more rapid inflow of foreign investment (Long, 2005).

What about changes in the tariffs imposed by trading partners? Figure 3b shows fluctuations in tariffs over time for China's most important trading partners: the NTR tariffs imposed by the U.S. and the average tariff rates imposed on Chinese exports by the European Union, Japan, Korea, and Taiwan. On average during this period, the U.S. is the destination for approximately 20% of Chinese exports, followed by the European Union at 17%, Japan at 12%, Korea at 5% and Taiwan at 2%. We again construct these rates as weighted averages of industry-level tariffs, utilizing the shares of total exports constituted by each industry's output in 1996 as weights. The estimated tariffs imposed by Korea are highest, but show no significant trend. Tariffs imposed by the U.S. and Taiwan decline gradually, and the tariffs imposed by Japan and the EU are roughly constant. In all cases, there is no evidence of any dramatic shifts in tariff rates at the point of China's WTO accession.[11] Despite their gradual nature, however, all of the preceding shifts in trade policy are relevant in understanding structural change during this period, and these variables will be included in our empirical specifications.

Importantly, there was a discontinuous jump in one important dimension of China's market access in 2001: the tariff uncertainty faced in the U.S. market. Prior to WTO accession, the United States granted China NTR tariff rates on a discretionary basis subject to annual congressional renewal. Failure of that renewal would have triggered the imposition of much higher tariffs, originally set by the Smoot-Hawley Act, and designated for non-market economies. Hence, although the tariff applied to Chinese imports remained low because China's NTR status was never withdrawn, the required annual approval generated considerable uncertainty. Using media and government reports, Pierce and Schott (2016b) document that firms perceived the annual renewal of MFN status as far from guaranteed, particularly in periods of political tension in the early 1990s.[12] The CEOs

[11] In Figure A1 in the Appendix, we provide an alternate representation of the evolution of both domestic tariffs and trading partner tariffs over time, utilizing county-level employment weights provided by the 1990 census to calculate a county-level weighted average tariff and then reporting the mean weighted county-level tariff by year over time. (These average county-level tariffs will subsequently be employed as control variables in the regressions of interest.) The graphs are largely similar, except that the tariffs imposed by Korea on Chinese imports appear much higher, reflecting Korea's extremely high tariffs on agricultural exports from China.

[12] Anecdotal evidence from the Chinese media has emphasized that China's WTO accession "will help build confidence among investors at home and abroad, especially among United States investors, because

of 340 firms stated in a letter to President Clinton that the "persistent threat of MFN withdrawal does little more than create an unstable and excessively risky environment for U.S. companies considering trade and investment in China, and leaves China's booming economy to our competitors" (Rowley, 1993).

In October 2000, Congress passed a bill that granted permanent NTR status to China, effective as of January 1, 2002. This was subsequently followed by a substantial spike in China's exports to the U.S., as evident in Figure 2a. The EU had granted China permanent NTR status much earlier (effective in 1980); thus, China did not face any tariff uncertainty in this market either before or after its WTO accession (Pierce and Schott, 2016b). The permanency of China's NTR status in other markets is ambiguous, but the descriptive evidence generally suggests there were no dramatic changes in the status of China's exports to other markets during this period, and analysts have noted that WTO members other than the U.S. had already provided China with permanent MFN status prior to its accession to the WTO (Rumbaugh and Blancher, 2004). Moreover, growth in China's total exports showed a trend almost exactly parallel to the observed growth in exports to the U.S., as evident in Figure 2b, consistent with the hypothesis that the increase in exports to other markets was minimal; we will also further substantiate this point in subsequent robustness checks.

Again, a number of policy shifts during this period shaped economic outcomes. However, we will preferentially focus on reduced trade uncertainty given that the previous literature has highlighted this shift had a major impact on the U.S. market, and given the discontinuous nature of the reduction in uncertainty. We will also present evidence that while the other reforms implemented during this period had a meaningful impact on local economic outcomes in China, the effect of reduced tariff uncertainty generally proves to be largest in magnitude. Our analysis allows us to separately identify the impact of tariff uncertainty vis-a-vis levels by exploiting the fact that tariff uncertainty varies only comparing the pre and post period, and is proxied by the difference between low tariff rates and the counterfactual high rates specified by the U.S. tariff schedule. By contrast, realized tariff levels imposed by both the U.S. and other trading partners vary continuously over time. Further details are provided in section 3.2.

China currently faces the issue of maintaining its Most Favored Nation trading status every year" (Shanghai Securities News, 1999). Chinese companies have also expressed that "[they] can enjoy multilateral Permanent Most Favored Nation status among the Member States of the WTO, so as to actively explore and enter the international market and participate in international economic competition" (Jiangxi Paper Industry Co. Ltd., 2000). Chinese newsletters described the U.S.'s decision to sever the ties between China's MFN status and human rights record as having "removed a major issue of uncertainty"; in addition, the renewal of China's MFN status would encourage investment and re-exports by "removing the threat of potential losses that would have arisen as a result of revocation" (South China Morning Post, 1994).

2.2 Conceptual framework

The reduction of tariff uncertainty can affect structural change through several channels. First, a reduction in tariff uncertainty creates incentives for Chinese firms to increase their exports to the U.S. market. A large literature has established that price uncertainty (in this case generated by tariff uncertainty in the destination market) generates an option value of waiting, decreasing investment (Bernanke, 1983; Dixit, 1989; Bloom et al., 2007). When tariff uncertainty is reduced, firms facing positive demand in the destination market, primarily manufacturing firms, have a greater incentive to make irreversible investments required to enter foreign markets (Handley and Limão, 2015, 2017). Given that industries differ in their exposure to tariff uncertainty, firms in industries with greater exposure ex ante will face a greater decline in the option value of waiting post-WTO accession. Exports from these tradable industries, and counties with a greater concentration in these exposed industries, will differentially increase.

Moreover, in the Chinese case, the effects of reduced uncertainty are plausibly concentrated in non-agricultural production. This primarily reflects the fact that international demand for Chinese agricultural products is minimal, and thus trade policy uncertainty is unlikely to be a meaningful constraint in this sector. In addition, the reduction in tariff uncertainty was much larger for non-agricultural production, suggesting that this shock is likely to disproportionately increase secondary exports.

Second, a reduction in tariff uncertainty induces U.S. firms to increase foreign direct investment (FDI) into China, as again the option value of delaying investment declines. In addition, export-oriented industries in China are generally characterized by high FDI, as foreign investors producing for export have benefited from a variety of preferential policies, including the exemption of imported components from import duties (Zhang and Song, 2000) and the establishment of preferential zones that offer reduced taxes on profits and other benefits (Cheng and Kwan, 2000). Accordingly, a growing export sector can be expected to attract increased FDI, and these effects would be particularly large in industries and counties more exposed to tariff uncertainty ex ante and those industries facing non-trivial foreign demand, primarily in manufacturing. This investment channel is, therefore, likely to enhance the structural change induced by the expansion of exports.

Third, the reduction in tariff uncertainty will induce a reallocation of productive factors across sectors. Increased demand for exports and increased FDI in the secondary sector will increase the returns to capital and labor, and this local reallocation effect implies an in-flow of productive factors (Acemoglu et al., 2016). On the other hand, an increase in exports and FDI at the county level generates positive local demand effects, benefiting producers of non-tradables, as well as any producers of tradables that sell partly to the local market. If there is some input in non-tradable (tertiary) production that is not mobile across sectors, this second, local demand effect will dominate the local reallocation effect (Kovak, 2013),[13] suggesting that reduced trade uncertainty will stimulate growth in both the secondary and tertiary sectors.

Finally, given nonhomothetic preferences, a positive local income effect will shift consumption away from agricultural and agricultural-derived goods, reinforcing the reallocation of productive factors toward the secondary sector (Uy et al., 2013; Gollin et al., 2014; Matsuyama, 2018). Shifting consumption patterns in conjunction with the local reallocation effect implies that the net effect on agriculture is likely to be negative. If there is considerable surplus labor employed in low productivity activities in agriculture, then labor reallocation may not lead to an immediate decline in agricultural output, as predicted by classic surplus labor models (Lewis, 1954; Fei and Ranis, 1964). In the presence of a sustained labor drain out of agriculture, however, agricultural output will decline over time in counties that are relatively more exposed to the trade shock.[14]

By examining economic outcomes at the level of counties, or local labor markets, we are able to capture both the direct effect of reduced uncertainty on the expansion of sectors that benefit from increased exports and increased FDI, as well as the indirect effects generated by the reallocation of productive factors and the expansion of local demand. Moreover, the reduction in tariff uncertainty may have disproportionate effects on counties with certain baseline characteristics. Since capital investments are generally irreversible, counties with an initially higher concentration of capital-intensive industries are likely to respond more robustly to the reduction in tariff uncertainty. Similarly, the effect of reduced tariff uncertainty is likely to be larger for counties that specialize in industries exporting a higher proportion of their output to the U.S. ex ante, as well as for counties that are more proximate to ports and thus face a lower transaction cost of exporting. We will also test these hypotheses in the empirical analysis.

3 Data

The empirical analysis incorporates three sources of data: county-level economic outcomes, the county-level NTR gap, and other policy shifts. We will discuss each data source in turn.

[13] The existing literature analyzing the response of U.S. local labor markets to Chinese trade shocks also finds that the local demand effect dominates local reallocation effects (Autor et al., 2013; Acemoglu et al., 2016).

[14] The presence of surplus labor in Chinese agricultural sector, and its decline over time has been well documented in the literature (Zhang et al., 2011; Kwan et al., 2018). Our estimates of the impact of tariff uncertainty reduction on structural change provide evidence in support of the hypothesis that stocks of surplus labor in rural China have been depleted, as we discuss in Section 4.1.

3.1 County-level data

The main outcomes of interest are economic indicators at the county level reported by provincial economic yearbooks. Each year, every province in China publishes a statistical yearbook, primarily reporting economic indicators for the full province or for larger aggregate units such as prefectures. However, most provincial yearbooks also include some economic indicators reported at the county level. These data were compiled and digitized for every year available between 1996 and 2014. (Each yearbook reports data from the previous year; thus, 2013 is the final year observed in the data.) To the best of our knowledge, this study is the first to construct a comprehensive county-level panel of economic outcomes for this time period.

Only one limitation is imposed on the sample. We exclude provincial-level autonomous regions: Tibet, Xinjiang, Ningxia, Inner Mongolia, and Guangxi, as well as the island of Hainan, for which data is generally unavailable. Otherwise, all counties that can be matched between the 1990 county census and the provincial yearbooks are included. Aggregated to the county level, the 1990 census reports data on 1994 units that are (approximately) at the county level in the provinces of interest; of these units, 91%, or 1805 counties, can be matched to the yearbooks.[15]

The county-level panel includes information on exports; GDP and employment by sector; and detailed information about investment in agriculture. GDP and employment are reported for the primary, secondary, and tertiary sectors. Again, the primary sector includes agriculture, fishing, and forestry; the secondary sector includes manufacturing and mining; and the tertiary sector includes services. (Agricultural employment is also reported as a supplement to primary employment, as it is available for a larger sample.)

Exports and GDP are reported in millions of yuan, and per capita GDP is reported in yuan. The nominal figures for GDP and exports reported in the provincial yearbooks are deflated using World Bank deflators. Additional variables capturing investment in agriculture include cultivated area (reported in thousands of hectares), agricultural machinery used (reported in 10,000 kilowatts), grain and partial cash crop output (reported in thousands of tons), and grain yield (reported in tons per hectare).[16]

Summary statistics are reported in Table 1; for each outcome variable, the mean in logs is reported, followed by the mean, minimum and maximum in levels. While the

[15]The 1990 census has one unusual characteristic that differentiates it from subsequent census rounds (2000 and 2010) and from the provincial yearbooks: data for prefecture-level cities are reported only at the prefecture level, not for the constituent county-level units. In some cases, provincial yearbooks report data for these county-level units of prefecture cities. Accordingly, a single census observation can in these cases be linked to multiple county-level observations in subsequent waves of yearbook data.

[16]The production of cash crops is calculated as the sum of the production of meat and edible oils, the most commonly reported cash crops. This is clearly an incomplete measure of cash crop production, but allows us to generate some evidence about evolution of non-staple cultivation.

log variables are used for analysis, the summary statistics in levels are also included for descriptive purpose. The average population in the sampled counties and years is approximately 500,000. Per capita income is approximately 10,000 yuan or $1300.

Missing data Data is missing from the county-level panel for two reasons: counties cannot be matched between the census and the provincial yearbooks, and counties are matched to the yearbooks but specific indicators are not available. Here, we will briefly discuss each case; a detailed discussion can be found in Section A1.1 in the Appendix.

First, some counties that are observed in the census do not appear in provincial yearbooks. These are disproportionately counties that are part of larger, prefecture-level cities, as some provinces omit data for these areas. Accordingly, any bias due to missing counties will orient the sample toward rural areas that are not already fully industrialized. The differences between counties observed and not observed in provincial yearbook data are summarized in Table A1 in the Appendix, in which we estimate a series of specifications regressing county covariates as observed in the 1990 census on a dummy for missing, conditional on province fixed effects. The results suggest that counties missing from the sample are characterized by larger populations, higher levels of education, and a greater concentration of labor outside of agriculture.

Second, for those counties that are observed in provincial yearbooks, different provinces in different years opt to report different indicators at the county level in their yearbooks. As a result, the number of observations varies significantly for different variables, as evident from the summary statistics. The indicators that are reported most infrequently include employment at the sector level and exports, while indicators reported near-universally include gross domestic product, total employment, population, and measures of agricultural inputs and production.[17] (For each variable presented in Table 1, we also note the number of counties reporting any data for that variable. This figure ranges between 1000 and 1700.)

We also present further evidence in Table A2 in the Appendix that the number of observations for the key variables of interest is in general lower for more populous counties, and higher for those that are more agricultural and have a lower proportion of employment outside the primary sector. This is again consistent with the underrepresentation of more urban and industrialized counties in the sample. We will subsequently demonstrate that the primary results are all robust to controlling for patterns of selection into the sample. In addition, we will present evidence around the evolution of exports and secondary employment — key outcomes of interest that are infrequently reported in the county-

[17]In particular, a strong positive correlation exists between the probability of reporting any data on export sales value and county-level GDP, and six relatively poor provinces (Shanxi, Sichuan, Guizhou, Shaanxi, Gansu, and Qinghai) report almost no data on exports

level data — drawing on additional data sources.

3.2 County-level NTR gap measure

Our empirical analysis seeks to identify the effect of the substantial reduction in tariff uncertainty in the U.S. market that China experienced following its accession to the WTO. To estimate the impact of China's permanent NTR status, we define the NTR gap at the industry level for each of the 39 subsectors of tradable production represented in the census data.

$$NTR\,Gap_i = Non\,NTR\,Rate_i - NTR\,Rate_i \tag{1}$$

The $Non\,NTR\,Rate_i$ is the higher tariff rate that would have applied if the U.S. Congress had revoked China's annual NTR status for industry i, and the $NTR\,Rate_i$ is the lower tariff rate guaranteed by permanent NTR status.

The industry-level NTR gap data were constructed by Pierce and Schott (2016b) using ad valorem equivalent NTR and non-NTR rates. The NTR gap for industry i is the average NTR gap across the four-digit ISIC Revision 3 tariff lines belonging to that industry. Throughout the empirical analysis, we use the NTR gaps for 1999, two years before the U.S. granted China permanent NTR status.[18] We manually match the industry categories in ISIC Revision 3 to the industry categories reported in the Chinese employment data, and Table A4 in the Appendix provides the details associated with this matching.

We then construct a county-level NTR gap measure equal to the weighted average of industry gaps, where the baseline composition of employment by industry prior to WTO accession is used to construct the weights. More specifically, we utilize the employment data reported in the 1990 census to calculate the share of tradable employment by industry in each county, interacting the NTR gap faced by industry i with each industry's county-specific employment share.

$$NTR\,Gap_c = \sum_i empshare_{ic}^{1990} \times NTR\,Gap_i \tag{2}$$

Given that each county's sectoral composition prior to WTO accession is used to construct the employment shares, the NTR gap does not reflect endogenous changes in employment composition that are driven by reduced trade policy uncertainty. Counties characterized by a larger NTR gap experience a greater reduction in trade policy

[18] We follow Pierce and Schott (2016b) in utilizing the 1999 NTR gaps. These NTR gaps are almost identical to those in 2000 or 2001; accordingly, the results are robust to the use of data from other years.

uncertainty post–2001, and thus ceteris paribus should show greater expansion in export-oriented industries. Permanent NTR rates were effective for China as of January 1, 2002, and thus our analysis characterizes all years from 2002 onward as the post-reform period.

In addition, we preferentially employ the employment shares observed in the 1990 census rather than the 2000 census to minimize potential endogeneity in employment composition. We hypothesize that by 2000, counties with more informed leaders or enterprises with more foresight may have already shifted toward subsectors that were less exposed to trade policy uncertainty. This would generate some correlation between county-level unobserved characteristics and the size of the county NTR gap. We will subsequently demonstrate that the results are robust to the use of 2000 employment weights, and are also consistent when the employment shares are recalculated with respect to total employment (including non-tradable employment).[19]

Table A5 in the Appendix summarizes the NTR gap observed for each industry. The highest NTR gaps are observed for textiles, garments, other manufacturing, medical and pharmaceutical products, and furniture manufacturing; the lowest NTR gaps are observed for mining products and agricultural output. At the county level, the average NTR gap is .123 with a standard deviation of .043. Approximately 5% of counties face NTR gaps of more than 20%. Figure 4 shows a histogram of the NTR gap at the county level. While there is some evidence of outliers, we will demonstrate that the primary results estimated in Section 4.1 are robust to winsorizing the NTR gap. Figure A2 in the Appendix shows a map of cross-country variation in the NTR gap, utilizing the residuals after the NTR gap is regressed on province fixed effects. Overall, there is substantial variation in exposure to reduction in tariff uncertainty across Chinese counties.

3.3 Other policy changes

In the main empirical analysis, we also consider a number of other policy changes in China and the U.S. to isolate the impact of China's accession to the WTO. In particular, we examine whether other policy shocks could be the cause of the structural change that China has experienced over the past decade. Other policy shocks may constitute plausible alternative explanations if their timing coincides with China's WTO accession and if these shocks would disproportionately affect counties that are more exposed to

[19] Data on GDP, revenue, and export value per subsector are not available in any year; accordingly, weights can only be constructed using employment data. Constructing measures of exposure to trade shocks using employment weights is common in the literature, and a theoretical justification has been provided in Kovak (2013). Employment weights are also employed by Topalova (2007, 2010), McCaig (2011), Kovak (2013), and Autor et al. (2013) in analyzing the effects of trade exposure on poverty and local labor market outcomes in regional labor markets in India, Vietnam, Brazil, and the United States, respectively.

reduced tariff uncertainty post–2001. As previously noted, major domestic reforms in this period included lower import tariffs, the elimination of import licensing requirements, and reduced restrictions on FDI.

In our regressions, we use data on China's import tariffs from the WITS–TRAINS database, data on export licensing requirements from Bai et al. (2017), and data on the nature of contracting from Nunn (2007) to control for these policy changes. The data on the nature of contracting provide a measure of the proportion of intermediate inputs employed by a firm that require relationship-specific investments by the supplier; counties with high concentrations of industries characterized by different contracting methods may be differentially affected by reductions in barriers to foreign investment. For each of these variables, we construct a county-level weighted average from the industry-level source data using employment weights from the 1990 census.[20]

We also control for policy changes in the U.S., including the time-varying NTR rate itself, for which we construct an industry-weighted county average. An additional important policy shift during this period was the elimination of textile and clothing import quotas in 2002 and 2005 as part of the global MFA. We employ data on MFA quotas from Khandelwal et al. (2013b), and follow their methodology to construct a measure of the degree to which industries' quotas were binding under the MFA by calculating the import-weighted average fill rate. The fill rates represent the ratio of actual imports to allowable imports under the quota; thus, a higher value indicates greater exposure to MFA quota reductions. Using these industry-level data, we construct a county-level MFA variable, where greater values represent greater exposure to quota reductions and thus greater benefits from the policy shift.

4 Empirical results

In this section, we first analyze the baseline specification focusing on pre-post differences, and demonstrate that the results are robust to alternate specifications. Next, we present evidence that counties with high and low NTR gaps are characterized by parallel trends prior to 2001, but diverging economic trajectories post-accession, and also examine heterogeneous effects. Finally, we draw on additional data from a survey of large-scale firms.

[20] Since the industry categories for the export licensing and contract intensity variables are available for SIC categories, these categories are manually matched to the census employment categories. The industry classification for the import tariff data is available in ISIC Revision 3, the same source utilized to construct the NTR gap variable. Table A4 in the Appendix provides the details associated with the matching.

4.1 Baseline specification

First, we use a difference-in-difference specification to analyze the effect of reduced trade policy uncertainty on county-level economic outcomes. More specifically, we examine whether the trajectory of economic outcomes in counties characterized by relatively large gaps between NTR tariff rates and non-NTR rates is different following China's accession to the WTO in 2001. The sample includes annual county-level data from 1996 to 2013; all dependent variables are calculated as the log of the variable of interest.

We employ ordinary least squares (OLS) to estimate the following specification:

$$\begin{aligned} \ln(Y_{cfpt}) = {} & \beta_1 Post_t \times NTR\,Gap_{cfp} + \boldsymbol{X}'_{cfpt}\theta + \gamma_{pt} \\ & + Urb_{cfp} \times \gamma_{pt} + \delta_c + \epsilon_{cfpt} \end{aligned} \tag{3}$$

The dependent variable is observed in county c in prefecture f in province p in year t. The independent variable is the interaction of the county-level NTR gap, standardized to have a mean of zero and a standard deviation of one, with a post–WTO dummy, equal to one for 2002 and subsequent years.[21]

The specification also includes a number of additional controls denoted $\boldsymbol{X}'_{cfpt}$. This includes the interaction of the post dummy and a time-invariant dummy capturing whether the county is characterized by industries with high contract intensity.[22] We also control for time-varying shocks: the industry-weighted MFA quota fill rate for county-produced goods, the industry-weighted domestic import tariff rate, the industry-weighted percentage of local firms licensed to export, and the industry-weighted NTR tariff rates. (All variables capturing other changes in trade policy during this period are also included in the specifications estimated in Pierce and Schott (2016b); we will demonstrate in Section 5 that the results are consistent when estimated without these additional controls.[23]) The specification also includes province-year fixed effects, province-year fixed effects interacted with an urban dummy to allow for differential trends in urban areas, and county fixed effects.[24] Standard errors are clustered at the county level, and all specifications are weighted with respect to total county-level employment in 1990.

[21] The county-level NTR gap is omitted, given the inclusion of county fixed effects; similarly, the post dummy is collinear with province-year fixed effects.

[22] Specifically, this dummy is equal to one if the weighted average of industry contract intensity is above the mean.

[23] There are some differences between our specification and that employed in Pierce and Schott (2016b). They include the contract intensity variable in linear form and use the import tariff and export licensing variables to construct differences over time that interact with the post–WTO dummy. They also include other control variables for baseline capital and skill intensity and the use of high-technology products that are unavailable in our data.

[24] This dummy variable is equal to one if the county name includes the "shi" (i.e., city) suffix in 1990. Approximately 19% of the counties are designated as urban.

The results of estimating equation (3) are reported in Table 2; for concision, only the coefficient β_1 is reported. (The full set of coefficients is reported in Tables A6 through A8 in the Appendix, and will be discussed subsequently.) To analyze the magnitude of the effects, we will compare a county at the median level of uncertainty ex ante to a county characterized by the minimum level of uncertainty observed, a difference equal to one standard deviation in this sample; accordingly, the coefficients reported in the panel can be interpreted directly as the effect in log points. In Panel A, we observe that this increase would lead to an increase in exports of approximately .18 log points in the post–2001 period. There is also evidence of an increase in secondary, tertiary, total and per capita GDP of around .04 log points. No significant effects are observed for primary output. While the estimated effect for total GDP is larger than the effect for its subcomponents, the sample is also much larger for this variable. Accordingly, the observed pattern suggests that counties that do not report secondary and tertiary GDP in general show a larger response to the shock of interest post-WTO.[25]

Panel B reports the employment results; again, employment data are available for a more limited sample, and the results are thus more noisily estimated. There is weak evidence of a decline in primary employment, but the decline in agricultural employment (reported for a larger sample) is significant, and indicates an decrease of .07 log points. We observe an increase in secondary employment of .23 log points, but no shift in tertiary or total employment. The absence of any significant effect for total employment may be somewhat surprising, but the sample for total employment is again much larger; accordingly, this result suggests the decrease in primary employment and the increase in secondary employment may be of roughly equal magnitude in the full sample of counties. In addition, we observe a relative increase in population of .014 log points in counties ex ante more exposed to tariff uncertainty, suggestive of some, albeit limited, in-migration. Finally, Panel C reports the results for agricultural variables, suggesting that sown area, agricultural machinery, grain and cash crop production, and grain yield show consistent declines of between .04 and .12 log points.

Taken together, these results suggest a clear pattern. Counties with high concentrations of industries exposed to large gaps between NTR and non-NTR tariffs show evidence of significantly more expansion in the secondary sector following China's WTO accession—a pattern evident in increased employment and GDP—and this growth generates a reallocation of productive factors out of agriculture, and an increase in local GDP. If we assume that uncertainty is reduced to zero for a county at the median level

[25]Unfortunately, the county-level data do not report any information on imports. Data on imports are provided at the provincial level; analyzing the effect of the post-NTR gap interaction in a parallel specification estimated with data at the province-year level reveals only weak evidence of an increase in imports.

of uncertainty ex ante, the implied effect at the median is an increase of .12 log points in county-level GDP, and .1 log points in per capita GDP. As will be explored further in Section 5.3, these effects are of non-trivial magnitude relative to overall growth in this period.

The coefficients for the full set of control variables are reported in Tables A6 through A8 in the Appendix. In general, there is evidence of more rapid substitution away from agriculture in counties that benefit more from MFA quota reductions, and slower growth in secondary production in counties more exposed to a decline in domestic tariff rates and an increase in competition from imports. The coefficients on the post-contract interaction and the time-varying NTR rate are generally insignificant, and varying in sign. These patterns are consistent with the hypothesis that, while other trade reforms in this period were relevant for the evolution of county-level outcomes, no other policy shift had a positive effect on county-level expansion of exports and secondary production as large as that produced by reduced uncertainty in the U.S. market.[26] In some specifications, the coefficients on the domestic tariff rate are large in magnitude; however, as previously noted the majority of the reduction in domestic tariffs was observed prior to WTO accession, and the sign of the coefficient suggests a negative shock from domestic tariff reduction, rather than a positive shock.[27]

Structural transformation and the surplus labor hypothesis Appendix Table A10 reports additional specifications for key agricultural variables, including agricultural employment, sown area, output and primary GDP, in which we further explore the effects of the shock of interest on agricultural employment and output. First, in Panel A, we re-estimate the primary specification including an additional interaction between the NTR gap and a dummy variable for the post-2008 period. (This demarcation divides the 12 year post period for which data is observed, 2002–2013, into two periods of six years.)

[26] In Appendix Table A9, we also evaluate whether shifts in exchange rate policy could be a source of bias in these results; while exposure to different levels of tariff uncertainty is not directly correlated with exposure to exchange rate shocks, counties with a high ex ante share of U.S. exports could be differentially negatively affected by the gradual appreciation of the yuan vis-a-vis the dollar observed during this period. When we estimate a parallel specification interacting a dummy for high U.S. share of exports with annual fluctuations in exchange rates and a post dummy, we find no evidence of this pattern (Appendix Table A9), and similarly see no evidence of such a response in a simpler specification that does not take into account differences between the pre and post period. Thus, we conclude that renminbi undervaluation is not a significant source of bias in our primary estimates.

[27] A seeming anomaly can be observed here in that the proportion of firms licensed to export is negatively correlated with GDP. In the cross-section, we observe the expected positive correlation between the proportion of firms exporting and county-level GDP prior to 2004 (when export licensing requirements were eliminated). However, when county fixed effects are included, counties that show larger increases over time in export licensing are, mechanically, those with initially lower levels of export licensing, given that the maximum value for this variable is one. These counties with low initial export license levels are also characterized by slower GDP growth.

The decline in agricultural employment, sown area, and cash crop production accelerates later in the period, and there is also a significant decline in primary output.

Second, in Panel B, we estimate the mean NTR shock at the prefecture level and include this shock in the specification, in addition to the interaction between the county- and prefecture-level shock. The objective is to identify whether an agglomeration of positive shocks to the exporting sector generates an intensified pattern of substitution out of agriculture. Here, we can observe that the coefficients on the prefecture-level shocks are consistently negative; for the interaction effects, the interaction effect for agricultural employment is statistically insignificant, while the interaction effects for sown area, grain output, and primary GDP are significant and negative. This constitutes suggestive evidence that given an agglomeration of local shocks, the decline in output is larger in magnitude.

The observed decline in output given a reallocation of factors out of agriculture is inconsistent with classic models of surplus labor in agriculture (Lewis, 1954; Fei and Ranis, 1964). Rather, these results suggest that while there were some surplus labor stocks in the Chinese agricultural sector, these stocks have been declining over time, and declining more rapidly in regions where there have been consistent positive shocks to the secondary exporting sector. Accordingly, if the "pull factor" generated by reduced trade costs is persistent over time or over space in more exposed counties and prefectures, this factor reallocation ultimately stimulates contraction in primary output. These results are also consistent with other recent evidence arguing that stocks of surplus labor in China have largely been depleted (Zhang et al., 2011; Kwan et al., 2018).

Alternate estimates of the NTR gap In Table 3, we re-calculate the NTR gap using a number of alternate strategies to evaluate the robustness of these results, focusing on exports and GDP. In Panel A, we construct the NTR gap utilizing the employment data reported in the 2000 census to construct employment weights rather than utilizing the 1990 weights. The results are generally comparable, although the estimated coefficients for secondary, GDP and per capita GDP are slightly larger. The use of 2000 employment weights introduces two potential sources of bias: areas already industrialized by 2000 will generally have larger NTR gaps, while industrialized areas that are more strategic in investing in industries characterized by less tariff uncertainty may have lower NTR gaps. The latter phenomenon will lead to upward bias in the estimates of the effect of uncertainty reduction, and this upward bias does seem to be evident in these specifications.[28]

[28]The number of observations contracts slightly, as some county codes cannot be matched to the 2000 census; more details about the construction of the NTR gap variable using 2000 employment data are provided in Appendix A.14. These results are also consistent if we employ the mean of sector weights as observed in the 1990 and 2000 censuses.

In Panel B, we construct the NTR gap by weighting each subsector with respect to total employment, assigning a zero weight to the tertiary (non-tradable) sector. In our main specification, we estimate the NTR gap without considering the relative size of the services sector, weighting employment with respect to total tradable employment; this methodology is recommended by Kovak (2013), though earlier papers in the trade literature assign the non-tradable sector a weight of zero.[29] Using this alternate strategy to re-calculate the NTR gaps and re-estimate equation (3) yields consistent results.

As previously noted, in general the gap between NTR tariffs and non-NTR tariffs is relatively low for agricultural products compared with that for industrial products; this raises the potential challenge that the observed growth in high NTR gap counties post–2001 may primarily reflect more rapid growth for already more heavily industrialized counties. Another related source of bias may stem from the fact some of the highest NTR gaps are observed for textiles and garment manufacturing, sectors that also benefited considerably from the relaxation of the MFA quotas. While the main specification includes controls for county-level variation in quotas, bias could be introduced by any shocks to textile production that are not captured by this variable.

We will address both points by implementing a similar strategy: including additional control variables for employment shares in different sectors interacted with year fixed effects. First, we calculate the share of employment in the secondary and tertiary sector as observed in the 1990 census, construct separate quartile dummy variables for each employment share, and include interactions between the quartile dummy variables and year fixed effects in the primary specification. Second, we use the employment shares in the five sectors characterized by the largest NTR gaps (textiles, garments, other manufacturing, medical and pharmaceutical products, and furniture manufacturing), again construct five sets of quartile dummy variables, and interact these variables with year fixed effects. (We use quartile dummy variables rather than the continuous variables to flexibly allow for non-linear effects of variation in employment shares; the results are also consistent if we simply employ the linear variable.) The results are reported in Panels C and D of Table 3, and are consistent with the primary specification.

For all of the robustness checks reported in Table 3, parallel results for employment and agriculture are reported in Tables A12 and A13 in the Appendix. We again observe generally consistent results.[30]

[29]This strategy has been widely used; see, for example, Autor et al. (2013), McCaig (2011), Topalova (2007), and Topalova (2010).

[30]The only exception is the estimated positive coefficient for total population; this estimate is not fully robust.

Variation in sample size Again, the number of observations fluctuates in the main specifications because many provincial yearbooks do not report specific indicators of interest (particularly sectoral employment and exports). We report in each panel the number of unique counties observed in the sample for each variable; this number ranges between 1000 and 1700. We will subsequently present results derived from additional data sources — a survey of large firms and data reported at the provincial level — that will enable us to corroborate the observed patterns for secondary employment and exports.

In addition, we present in Section A1.1 in the Appendix a number of additional specifications exploring whether the results are robust to selection into the sample, including imposing a sample restriction to only county-years that report export data. We observe consistent results across a number of different specifications controlling for selection into the sample, suggesting that missing data is not a significant source of bias.

4.2 Pre-trends

Given that we attribute the observed patterns to the reduction in tariff uncertainty following China's accession to the WTO in 2001, a more demanding test of the assumptions of the difference-in-difference specification can be conducted by evaluating the correlation between the variables of interest and the NTR gap prior to 2001. To implement this test, we estimate a more complex specification, interacting the NTR gap with a series of dummy variables for two-year intervals. (A single variable captures the three-year interval 1999–2001.) Dummy variables for the years prior to 1997 are omitted, rendering 1996 and the small sample of pre-1996 observations the reference period. The specification of interest can thus be written as follows in equation (4), including the same control variables employed in the main specification.[31] Again, standard errors are clustered at the county level and the regressions are weighted with respect to initial county-level employment.

$$\begin{aligned} \ln(Y_{cfpt}) = & \sum_{y=1997}^{2013} \beta_y 1\{y = t, t+1\} \times NTR_{cfp} \\ & + \boldsymbol{X}'_{cfpt}\theta + \gamma_{pt} + Urb_{cfp} \times \gamma_{pt} + \delta_c + \epsilon_{cfpt} \end{aligned} \tag{4}$$

The coefficients are presented graphically for county-level GDP in Figure 5; we focus on GDP given that it is the variable reported for the largest sample. Figure 5a shows the specification including the full set of control variables, and Figure 5b shows the simpler specification estimated without control variables. We observe that the coefficients for

[31] In this specification, to increase precision we convert the MFA variable into ten dummy variables for each decile.

the NTR gap prior to 2002 are uniformly insignificant and generally small in magnitude. In particular, the absence of any significant effect in 1999–2001 is consistent with the evidence presented in Handley and Limão (2017) that China's new tariff status was not implemented until 2002.[32]

However, following China's accession to the WTO, the magnitudes of the coefficients for the NTR gap are increasing over the subsequent decade, and generally statistically significant. This evidence is consistent with the hypothesis that the NTR gap is uncorrelated with any variation in county outcomes pre–2001, but highly predictive of the economic trajectories observed in the same counties post–2001. The pattern of an effect that is consistently positive after 2001, but growing slowly in magnitude, is also consistent with the parallel evidence presented by Pierce and Schott (2016b), showing a gradual decline in manufacturing employment in the U.S. over the same period.[33]

The regression analogues to these results are presented in Columns (1) and (2) of Table 4. We can also test whether the estimated coefficients β are equal when compared across the pre-treatment period (the dummy variables for 1997–1998 and 1999–2001) and the post–2001 period. All of the pairwise tests except two allow us to reject the hypothesis that the pre and post coefficients are significantly different at the one percent level.[34]

As a final additional test of potential bias introduced by pre-trends, we construct the long difference in county-level primary and non-primary (i.e., secondary and tertiary) employment as observed between the 1990 and 2000 census (i.e., in the pre-WTO period). We focus on employment given that it is the only indicator reported consistently for all counties in both years. The primary specification is then re-estimated including as an additional control variable the two constructed long-difference variables interacted with the post dummy, in effect controlling directly for any differential post-accession trend in counties characterized by different pre-trends; a similar methodology is employed in Autor et al. (2013). The results of estimating this specification are reported in Panel E of Table 3 for exports and GDP, as well as in Panels E of Tables A13 and A12 in the Appendix for agricultural and employment outcome variables. The estimated coefficients are entirely consistent, suggesting that the scope for potential bias due to differential pre-trends is minimal.

To sum up, these results suggest that the observed divergence in economic trajectories

[32]While the early years of the period analyzed here coincided with the onset of the Asian financial crisis in 1997, China was not directly affected by the associated financial contagion due to its maintenance of capital restrictions and a non-convertible currency (Wang, 1999). While exports to Asian markets that were themselves affected by the crisis did decline, Chinese exporters producing primarily for rich country markets such as the U.S. were largely unaffected (Park et al., 2010). Accordingly, this shock should not be a source of bias in this analysis.

[33]The corresponding figure in their paper is Figure 4.

[34]The exceptions are the tests comparing the estimated coefficients for 1997–1998 and 2002–2003, in both specifications (with and without additional controls).

of counties subject to different gaps between NTR and non-NTR tariffs following China's WTO accession is primarily due to increased access to the U.S. market, leading to an increase in exports. These patterns first emerge in the early part of the post–2001 period, but they become steadily more pronounced over the subsequent decade.

4.3 Heterogeneous effects

We can also usefully extend this analysis to present some evidence regarding heterogeneous effects, identifying counties concentrated in industries that should show a more robust response to the reduction of tariff uncertainty. In particular, we focus on counties that are more capital-intensive, counties concentrated in industries that export a higher proportion of their output to the U.S., and counties that are more proximate to ports.[35]

The tariff uncertainty faced by exporting firms in China prior to WTO accession presumably had a more significant effect on capital utilization vis-a-vis labor utilization, given that capital investments are generally irreversible. While the county-level panel does not include any detailed information about capital investment that would allow for a direct test of this hypothesis, we can examine heterogeneous effects with respect to capital intensity of the industries observed in the county at baseline. Using a capital intensity variable constructed from a survey of large firms (described in more detail in Section 4.4), we calculate average capital intensity for non-state owned firms at the industry level in 1998, the first year of the panel, and construct a county-level proxy for capital intensity in the (non-SOE) secondary sector using the 1990 employment weights.[36] We then re-estimate equation (4) for counties below and above the baseline median level of capital intensity; to increase power, we use the simple specification without controls.

Similarly, the export data available at the county level do not report the destination of these exports. However, we can use the available UNCOMTRADE data on Chinese exports at the product-destination level to calculate the proportion of exports destined for the U.S. by industry in 1996, the first sample year. We then generate a county-specific weighted average, and again re-estimate equation (4) for counties below and above the baseline median level of U.S. export share. Finally, we calculate for each county the average distance between the centroid of the county and the five largest Chinese container ports. We then characterize a county as either non-proximate to a port (above the median of the cross-county distribution of average port distance) or proximate (below

[35]There are thirteen Chinese ports that are among the largest 50 ports in the world by shipping volume World Shipping Council (2018); the five largest of these are Shanghai, Shenzhen, Ningbo-Zhoushan, Hong Kong, and Guangzhou. Data on their geographic coordinates is drawn from the China Geo-Explorer offered by the University of Michigan China data Center.

[36]Information about capital intensity in the primary sector is not available, and thus it is excluded from this analysis.

the median), and re-estimate equation (4) for both subsamples.

The graphical results are presented in Figure 6. For counties below the median level of capital intensity at baseline, there is little evidence of any significant effects of the elimination of tariff uncertainty; by contrast, the effects are large and significant post–2001 for counties above the median level of capital intensity. A similar pattern is observed for counties below and above the median U.S. export share, and counties that are non-proximate and proximate to major ports.

The regression analogues to these results are reported in Columns (3) through (8) of Table 4. In Columns (3), (5), and (7) we observe no significant coefficients for low-capital intensity, low-U.S. share and non-port proximate counties. Columns (4), (6) and (8) report the results for high-capital intensity, high-U.S. share and port-proximate counties, and show coefficients that are insignificant in the pre-period, followed by positive and significant coefficients post–2001. If we again test the equality of coefficients pre- and post-WTO, the hypothesis that the pre and post coefficients are equal can uniformly be rejected for these specifications. This suggests that as expected, the effects are concentrated in counties for which uncertainty was more likely to be a binding constraint on capital investment, counties in which uncertainty was highly salient due to the presence of exporters focusing on the U.S. market, and counties in which the transaction costs of exporting were relatively lower due to proximity to ports.

4.4 Firm-level outcomes

The county-level data previously used do not include data on some key outcomes of interest: particularly, capital investment, foreign investment and wages. In addition, the data on secondary employment are very limited. As an additional source of evidence, we utilize the large-scale industrial survey collected from 1998 to 2008, a data source described in detail in Brandt et al. (2012). The data are collected in annual surveys conducted by the National Bureau of Statistics, and they include all state-owned industrial firms (in mining, manufacturing, and public utilities) and all non-state firms in the same sectors with sales above 5 million yuan. For this analysis, we restrict the sample to manufacturing firms.

A variety of firm-level outcomes are observed. Employment and the total wage bill are directly reported, enabling us to estimate the average wage per worker. The perpetual inventory method is used to estimate the capital stock, as the firm's founding year is also reported; the average growth rate observed at the province-sector level over the sample years is used to estimate average annual investment rates. We also use a similar method to calculate the stock of foreign-owned capital, and use the estimate of the capital stock to calculate firm-level capital intensity (the ratio of the capital stock to total employment).

For sales, profits and value added, we use the deflators constructed by Brandt et al. (2012) to construct constant-price estimates, and we again calculate value added per worker.

The firms can be geographically linked only to the prefecture, as county indicators are unavailable. Accordingly, we perform this analysis at the prefecture level; the dependent variables are calculated as the sum of the relevant firm-level variables within the prefecture and year, to capture the total size of the large-scale manufacturing sector. (For capital intensity, wage per worker, and value added per worker, the mean is employed.) All dependent variables are then employed in log form.

The NTR gap is constructed as the mean of the NTR gap across all constituent counties in the prefecture and is denoted Y_{fpt} for the NTR gap in prefecture f and province p. The same control variables are also included and are calculated as the prefecture-level mean, and province-year fixed effects and prefecture-level trends are included, in addition to a level control for the prefecture-level NTR gap.

$$\ln(Y_{fpt}) = \beta_1 Post_t \times NTR\,Gap_{fp} + \beta_2 NTR\,Gap_{fp} + \boldsymbol{X'}_{fpt}\theta + \gamma_{pt} + \nu_f t + \epsilon_{cfpt} \tag{5}$$

The results are reported in Table 5; again, the coefficients correspond to prefecture-level aggregates of the firm data. The first three columns in Panel A show that a one standard deviation increase in the prefecture-level NTR gap is associated with increases in employment, capital and foreign capital of between .05 and .15 log points. Given that the expansions of capital and labor are of roughly equal magnitude (albeit slightly larger for capital), there is no significant shift in capital intensity, as reported in Column (4). Finally, in Columns (5) and (6), we observe that the total wage bill and the average wage per worker both increase.

In Panel B, we report results for additional outcomes: sales, value added, profits and value added per worker. Again, the coefficients are positive, and significant with the exception of profits, for which the coefficient is noisily estimated. The magnitude suggests a one standard deviation increase in tariff uncertainty is associated with increases of around .1 log points post–2002. These coefficients are generally somewhat larger than those employing county-level data, suggesting that the effects of reduced tariff uncertainty may be larger for above-scale firms.[37]

Additional province-level data Given that exports is reported for only a small sample of counties, and foreign direct investment is reported only in the firm-level data, we

[37]In addition, 20% of the firms in this sample are state-owned or collective firms; on average, the level of exports observed in these firms is approximately one-sixth the level of exports observed for non-state firms. In general, the observed effects are smaller in magnitude and often insignificant in the subsample of state-owned firms, though the differences comparing state-owned and non state-owned firms are not statistically significant.

also present additional results using data at the province level on exports and foreign direct investment for the full sample of provinces from 1996 to 2013. We then re-estimate the primary specification in parallel including the same control variables, all calculated as provincial-level means; the dependent variables include exports, total foreign capital used, foreign loans, and direct foreign investment. All are calculated as the log of real values in millions of yuan.

The results are reported in Table A11 in the Appendix, and show coefficients that are consistently positive and significant. The magnitudes suggest a one standard deviation increase in tariff uncertainty ex-ante is associated with increases of around .2 log points in exports and .5 log points in foreign direct investment. These results corroborate the previous evidence around an increase in exports and foreign direct investment in counties previously more exposed to tariff uncertainty.

4.5 Mechanisms

Returning to the conceptual framework, it is useful to highlight the mechanisms that generate the observed patterns of accelerated structural transformation post-WTO accession in counties more exposed to ex ante tariff uncertainty. First, we observe both a substantial increase in exports and an increase in foreign direct investment. Both effects are evident in data from a range of complementary sources. Second, as previously noted, there is fairly robust evidence of substitution of productive factors out of agriculture in counties characterized by higher ex ante NTR gaps following WTO accession. Third, we observe increased investment and output in both the secondary and tertiary sectors, although the effects are larger in the secondary sector.

The growth of the secondary sector as the primary sector shrinks is consistent with both the reallocation and the local demand channels. However, the fact that non-tradable (tertiary) production is expanding suggests that the local demand effect dominates the reallocation effect for the tradable sector. In addition, the substitution of factors out of agriculture is consistent with a reallocation effect driven by both increased secondary exports and rising income, assuming non-homothetic preferences. Importantly, this reallocation also generates contraction in primary output (at least in the medium term), suggesting that surplus labor stocks in agricultural production are declining or depleted.

In addition, we can document that the reduction in tariff uncertainty seems to generate an increase in returns to factors in the secondary sector in the medium-term, as evident in the persistent increase in wages and value added per worker observed in the firm data. The persistence of the observed effects is consistent with the hypothesis that there are barriers to full mobility of capital and labor that slow the equalization of factor returns across counties. (The gradual leveling in the post-accession trends evident in Figure 5 suggests that the observed effects of the uncertainty reduction may be moderating over time, perhaps as barriers to factor reallocation are reduced, enabling convergence between high-NTR gap and low-NTR gap counties; however, this evidence must be considered to be tentative.) Alternatively, there may be positive agglomeration effects in export production that lead to persistently more rapid growth in counties that benefit from the reduction in tariff uncertainty post-WTO.

5 Additional robustness checks

In this section, we present additional robustness checks, including placebo tests corroborating the hypothesis that the main effects are driven by reduced uncertainty in the U.S. market, and specifications evaluating potential bias due to reform of state-owned enterprises and utilizing night-lights data. We also summarize the overall economic significance of the observed effects.

5.1 Placebo analysis

Throughout this analysis, we have assumed that the discontinuous shock experienced by China at the point of its WTO accession is a decrease in tariff uncertainty in the U.S. market. Here, we implement two placebo analyses to evaluate this assumption. As previously noted, the EU endowed China with permanent NTR status in 1980, long before the latter's accession to the WTO, and other trading partners (excluding the U.S.) followed suit. Accordingly, China faced no tariff uncertainty in non-U.S. markets during the period of interest here.

We conduct two placebo tests. The first uses data from the UNCOMTRADE database reporting China's exports to all destinations at the 2-digit product level from 1995 to 2013. We then estimate a simple regression in which the dependent variable is the log of total export value of product p to destination country d in year t. The independent variables include a post dummy interacted with the U.S. NTR gap at the product level and a dummy for the U.S., and the post-NTR interaction interacted with a dummy for the other four top export destinations (the EU, Japan, Korea, and Taiwan). The specification also includes controls for the product-specific tariff imposed by each of the five major destinations on each product, summarized $\boldsymbol{X}_{pdt}$, and product-year fixed effects.

$$\begin{aligned}\ln(Exp_{pdt}) = {} & \beta_1 NTR_{pt} \times US_d \times Post_t + \beta_2 NTR_{pt} \times Other_d \times Post_t \\ & + \boldsymbol{X}_{pdt} + \omega_{dt} + \epsilon_{dpt}\end{aligned} \tag{6}$$

We hypothesize that β_1 will be positive and significant, and β_2 will not be significantly different from zero: products characterized by a larger NTR gap exhibit a disproportionate increase in exports to the U.S. post-WTO accession, but there should be no significant increase in exports to other major destinations. The results are reported in Panel A of Table 6; in Columns (3) and (4), quadratic controls for tariffs are also included. Columns (1) and (3) include standard errors clustered at the partner level, and Columns (2) and (4) include standard errors clustered at the product level. We can observe that β_1 is positive and β_2 is negative and insignificant, consistent with the hypothesis that the key immediate shock experienced with WTO accession was a reduction in trade uncertainty in the U.S. market, not a shock in other major export destinations.

Second, we construct an artificial "other trading partners gap", comparing the highest tariff rates imposed by other major trading partners — the EU, Japan, Taiwan and Korea — to the tariff rates imposed by the same trading partners on Chinese goods. For each other trading partner (e.g., the EU), we identify for each industry a "maximum tariff" imposed by the EU on imports of that good.[38] We then calculate a placebo "other trading partner gap" equal to the difference between this high tariff and the tariff imposed on Chinese goods, and calculate the weighted average across the four major non-U.S. trading partners using as weights the share of total Chinese exports shipped to that destination.

The same procedure used to construct the NTR gap is then used to construct a county-level "other trading partners gap". The intuition is as follows: if Chinese exporters did in fact perceive any tariff uncertainty in other non-U.S. markets, the gap between the realized tariff on Chinese goods and the highest observed tariff is a proxy for the magnitude of this uncertainty, and the constructed "other tariff partner" gap thus captures uncertainty in other markets. If WTO accession reduced this uncertainty, we should expect parallel results when the primary specification is re-estimated with the placebo gap.

To test this hypothesis, we estimate the primary specification using the other trading partner county-level gap, including the same control variables and fixed effects included in the main specification. We also control flexibly for the other trading partner high tariff rate $Other_{cfpt}$.[39]

$$\ln(Y_{cfpt}) = \beta_1 Other\, Gap_{cfpt} + Other_{cfpt} + \boldsymbol{X'}_{cfpt}\theta + \gamma_{pt} + Urb_{cfp} \times \gamma_{pt} + \delta_c + \epsilon_{cfpt} \quad (7)$$

The results are reported in Table 6, and the estimated coefficients are small in magnitude, insignificant and varying in sign. This suggests that there is no evidence that tariff variation presumed to be orthogonal to China's export expansion predicts cross-county

[38] More specifically, we use the mean of the five highest tariffs observed.

[39] Specifically, we generate a set of dummy variables for each two-percent range in the distribution of the high tariff rate (50 dummy variables in all) and include these variables, as well as their interaction with the post dummy.

variation in economic outcomes.

5.2 Alternate specifications

To further explore the robustness of the primary results, we report a number of alternate specifications in Tables A14 and A15 in the Appendix. Again, we focus on exports and GDP as outcome variables. In Panel A of Table A14, we estimate the baseline specification including only province-year and county fixed effects. In Panel B, we include the full set of controls and weight each county observation by its 1990 population, rather than employment.[40] In Panel C, we winsorize the NTR gap above the 99th percentile and below the first percentile. In all three cases, the results are observed to be consistent.

In Panel A of Table A15, a full set of interactions between year fixed effects and a dummy variable for each quartile of initial GDP are added. In Panel B, we characterize counties based on the proportion of the population in 1990 reported to have post-primary education (on average, only a third), generate dummy variables for counties in each quartile of initial education, and include the interactions between these education quartile dummy variables and year fixed effects. In Panel C, we calculate a Herfindahl index capturing initial concentration in the tradable (primary and secondary) sectors and include interactions between dummy variables for each quartile of the Herfindahl index and year fixed effects. The results are again uniformly consistent.

There is also substantial expansion in China's agricultural imports from the U.S. during this period, particularly in cotton and soybeans.[41] We can utilize data from the 2000 World Census of Agriculture (FAO/IIASA) to analyze the cross-sectional correlation between the NTR gap and the proportion of area sown in soybeans and cotton. In general, this correlation is negative, suggesting that areas experiencing more export-driven growth are less subject to competition from imports. If we re-estimate the main specification including an interaction term between high cotton and soybean production (a dummy for the fraction of sown area devoted to cotton and soybeans being above the median) and the NTR gap, the interaction terms are generally insignificant, as reported in Panel D of Table A15.[42] Accordingly, competition from imports is not a channel that seems to be of first-order importance in generating the observed substitution away from agriculture.

Evidence around state-owned enterprises An additional robustness check explores whether the reform of state-owned enterprises (SOEs) could be an alternate channel for

[40] A small number of observations are missing population data. The results are also consistent if the regressions are weighted with respect to initial total GDP.

[41] Figure A3 in the Appendix shows the evolution of China's agricultural imports over time.

[42] The specification also includes interactions between dummies for each quartile of the cotton and soybean fraction variable, measured at the prefecture level, and year fixed effects.

the observed pattern. In addition to the market liberalization implemented in this period linked to WTO accession, a major restructuring of SOEs was implemented starting in the mid-1990s and accelerating in the latter part of the decade (Naughton, 2007).

Unfortunately, no county-level data are available on SOE employment. However, we can construct a county-level proxy using data on SOE employment in broad sectors (agriculture, mining and manufacturing) in each province as a percentage of total sector employment in that province in 1996 (the first year in the sample). We then use the 1990 employment weights by sector to construct a county-level average.[43] Cross-county variation in the imputed baseline share of SOE employment is thus generated by variation across counties in the salience of agriculture, mining and manufacturing, and variation across provinces in the relative importance of SOE employment in these three sectors.

Finally, we construct dummy variables for counties in each quartile of the initial imputed SOE fraction, and interact these dummies with year fixed effects in the main specification. The results are reported in Panel E of Table A15, and they are entirely consistent with the main specifications, suggesting that initial cross-county variation in the salience of SOE employment is not a significant source of bias.

Addressing measurement error To address the potential challenge introduced by measurement error or selective misreporting in county yearbook data, we employ two strategies. We begin by re-estimating the results employing as the dependent variable the average night lights index within county borders as a proxy for the intensity of local economic activity. We observe a correlation of .65 between the night lights index and reported county-level GDP, and when the primary specification is re-estimated using the night lights index as a dependent variable, the estimated relationship is significant and positive at the one percent level. The estimated magnitude suggests that a county at the median level of tariff uncertainty ex ante shows evidence of a 17% relative increase in night brightness post-2001 compared to a county at the minimum level of tariff uncertainty. The robustness of our results suggests that bias due to misreporting is of limited salience.

We also conduct an additional test to evaluate whether there may be selective misreporting in statistical yearbooks that could be correlated with the shock of interest. We focus on county-level GDP given that this is plausibly the measure that is most likely subject to manipulation, and construct a balanced panel of the counties for which GDP data is reported every year between 1998 and 2010.[44] We then calculate a province-year

[43] These employment data are drawn from the national statistical yearbooks; data on SOE employment in the highly disaggregated subsectors reported in the census are unavailable until much later, in the post–WTO period. Unsurprisingly, SOE employment is close to zero in agriculture (averaging 2%) and near universal in mining (averaging 91%). The SOE share in manufacturing employment is variable, with a mean of 38% and a standard deviation of 13%.

[44] These years are employed as the start point and end point of the period because availability of data

level sum of GDP, adjust this sum to reflect the percentage of total employment within a given province represented in the balanced panel of counties, and calculate a variable denoted "GDP gap" equal to the percentage gap between this figure and total reported GDP at the provincial level according to the National Bureau of Statistics. The GDP gap is thus designed to capture any systematic misreporting in county statistics.

To evaluate whether the GDP gap is correlated with the shock of interest, we regress the gap at the province-year level on the NTR gap and the post-NTR interaction, with and without province and year fixed effects and additional controls. The results are reported in Table A16 in the Appendix, and show uniformly insignificant results. This suggests that there is no evidence of systematic variation in the quality of GDP reporting that is correlated with cross-provincial variation in the NTR gap.

5.3 Aggregate productivity and growth

Finally, it may be useful to present some simple back-of-the-envelope calculations that quantify the contribution of the reduction in trade uncertainty generated by WTO accession to shifts in aggregate productivity and growth in China over this period. First, we can quantify the contribution of labor reallocation across sectors (from agricultural production to non-agricultural production) to aggregate productivity, following McCaig and Pavcnik (2014b). A growing literature has documented that value added per worker is significantly higher in non-agricultural compared to agricultural production in developing countries (Gollin et al., 2014), and we can replicate this stylized fact using limited data reported at the county level on value added per worker; value added per worker in the secondary sector is approximately 6.5 times value added per worker in the primary sector.[45] If we re-estimate the employment specification for agricultural employment in levels (i.e., re-estimating equation (3) using primary employment in levels as the dependent variable), the results suggest that around 4% of the total labor force shifted into non-agricultural production following WTO accession, implying an increase of around 10% in aggregate productivity driven by this reallocation alone.[46]

We can also explore the importance of WTO accession in overall growth in county-

contracts sharply before 1998 and after 2010. 20 provinces are represented in the balanced panel for 13 years each, yielding a sample of 260 observations; the provinces that are dropped do not have any counties reporting GDP data for this full period.

[45]The sample reported for value added per worker is not sufficient to utilize it as an outcome in the primary results.

[46]This calculation ignores any possible labor reallocation into the tertiary sector, for two reasons. First, there was no significant evidence of an increase in tertiary sector employment in the primary results, although these results may be limited by the small sample. Second, it is not possible to estimate value added per worker in the tertiary sector, as value added in this sector is not generally reported. In addition, to be conservative we use the estimated coefficient for the decline of employment in the agricultural sector, rather than the (larger) estimated increase in employment in the secondary sector.

level GDP during this period; more details about how these calibrations are conducted can be found in Appendix A1.2. The average county in this sample shows growth in county-level GDP of 1.2 log points in the post-WTO period. Our results suggest that for a county characterized by an NTR gap at the mean prior to WTO accession, the reduction in tariff uncertainty in the U.S. market to zero results in an increase in GDP of .1 log point. Accordingly, export-driven growth enhanced by WTO membership accounts for approximately 10% of overall GDP growth. A similar calculation for secondary GDP suggests that growth driven by the WTO accession shock accounts for approximately 9% of overall secondary growth from 2002 to 2010, the final year in which secondary GDP is observed for a substantial sample.

6 Conclusion

In this paper, we use a new panel of county-level data to present the first evidence of the effect of China's accession to the WTO in 2001—a policy shift that removed uncertainty over the tariff rates that Chinese exporters would face in the U.S. market—on structural transformation and growth. The identification strategy exploits variation across industries in the size of the gap between the MFN tariffs and the higher tariffs that Chinese producers risked exposure to prior to WTO accession, as well as variation across counties in the baseline composition of employment in the secondary sector. We then evaluate whether counties with a high concentration of industries characterized by large tariff gaps show more rapid growth post–2001.

Our results suggest that counties that benefited most from the reduced tariff uncertainty show substantial expansion following WTO accession. Employment and GDP in the secondary sector increase, while the agricultural sector contracts. Importantly, we observe not only a decline in employment in the agricultural sector but also a decline in output, a result inconsistent with predictions of the surplus labor hypothesis. We also observe a substantial increase in GDP per capita. Moreover, these patterns are observed only after 2001, suggesting that they do reflect the hypothesized channel of reduced tariff uncertainty, and are not evidence of ex ante differences in observable characteristics comparing across counties with larger and smaller NTR gaps.

This paper is the first to present evidence on the impact of the reduction in tariff uncertainty on structural transformation at the local level in China, and joins a relatively small literature analyzing the effects of enhanced trade access in stimulating growth in developing countries. These results highlight the importance of securing access to developed country markets for developing countries that pursue export-driven growth strategies. Understanding the implications of U.S. trade for Chinese growth may contribute to a more complete understanding of the global impact of rising U.S.–China bilateral trade and China's rise as a global manufacturing powerhouse over the past two decades.

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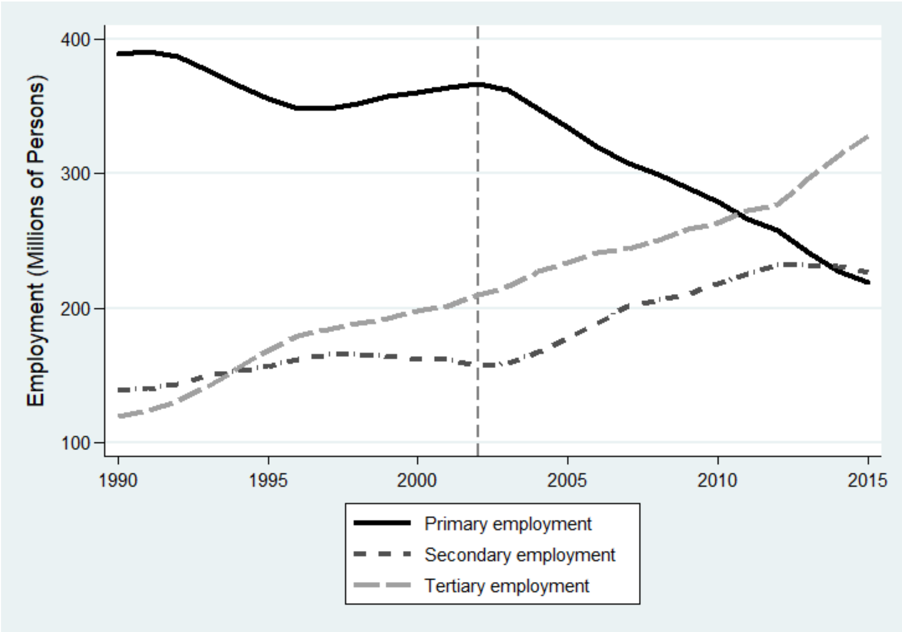
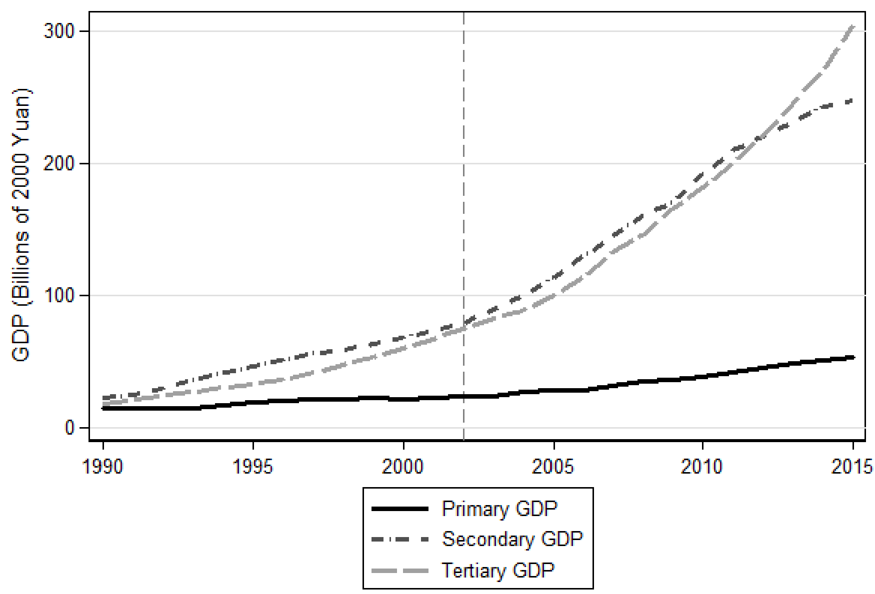
7 Figures and Tables

Figure 1: Composition of Employment and GDP in China

(a) Employment



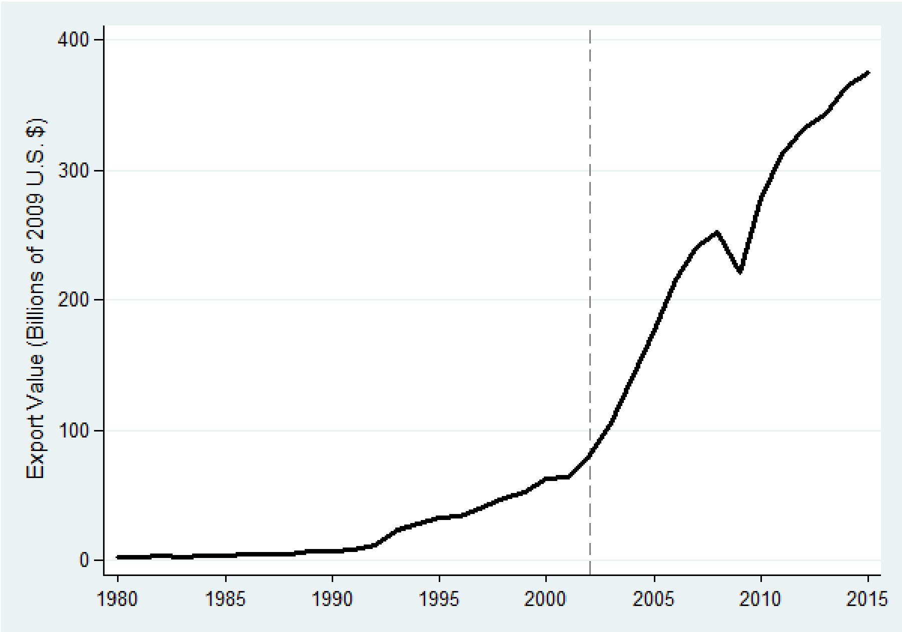
(b) GDP



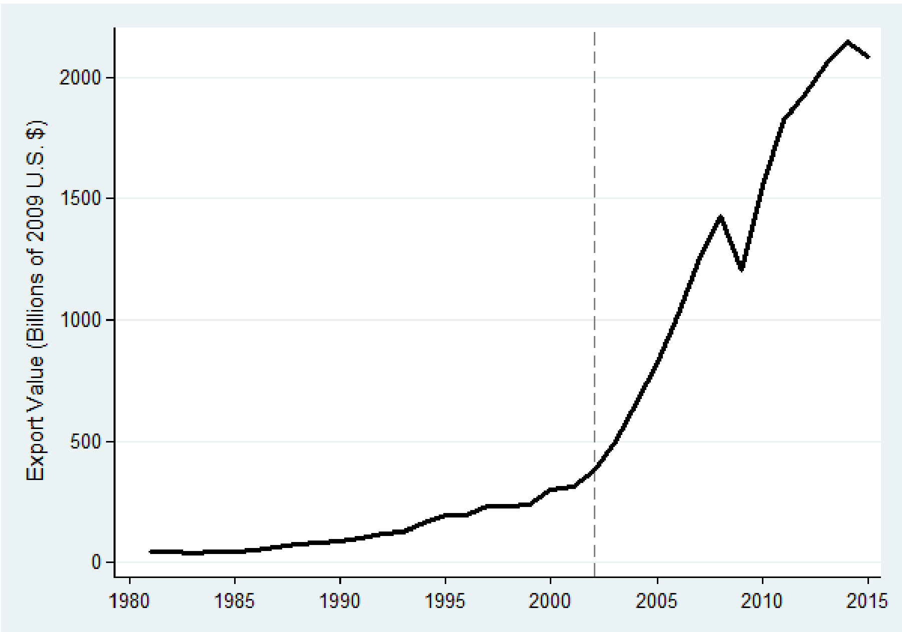
Notes: This graph presents aggregate statistics for China as a whole from 1990 to 2015, employing data from the National Bureau of Statistics. The primary sector includes agriculture, forestry and fishing, the secondary sector includes manufacturing and mining, and the tertiary sector includes services. GDP is reported in billions of constant 2000 yuan. Employment is reported in millions of persons.

Figure 2: China's Exports to the United States and the World

(a) China's Exports to the United States



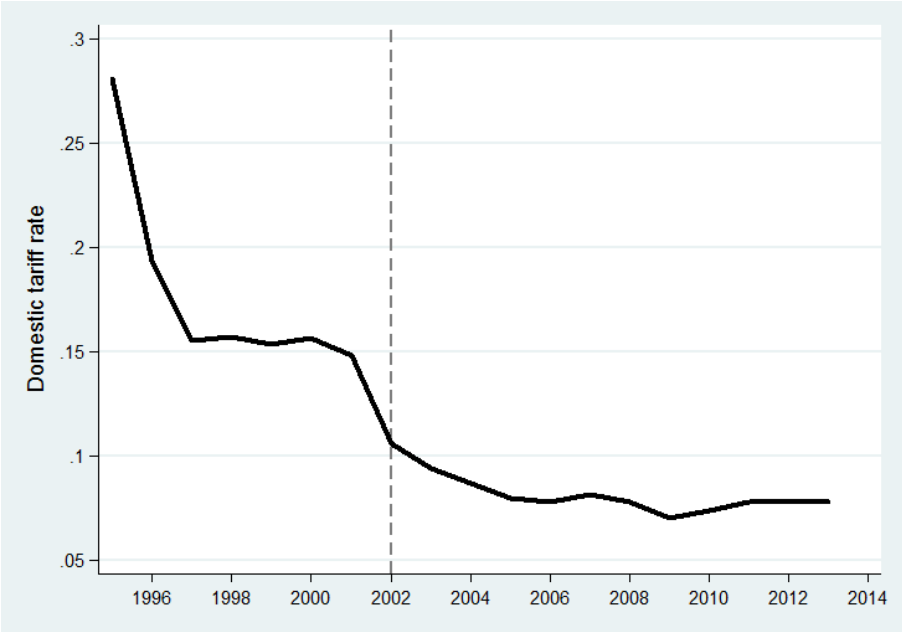
(b) China's Total Exports



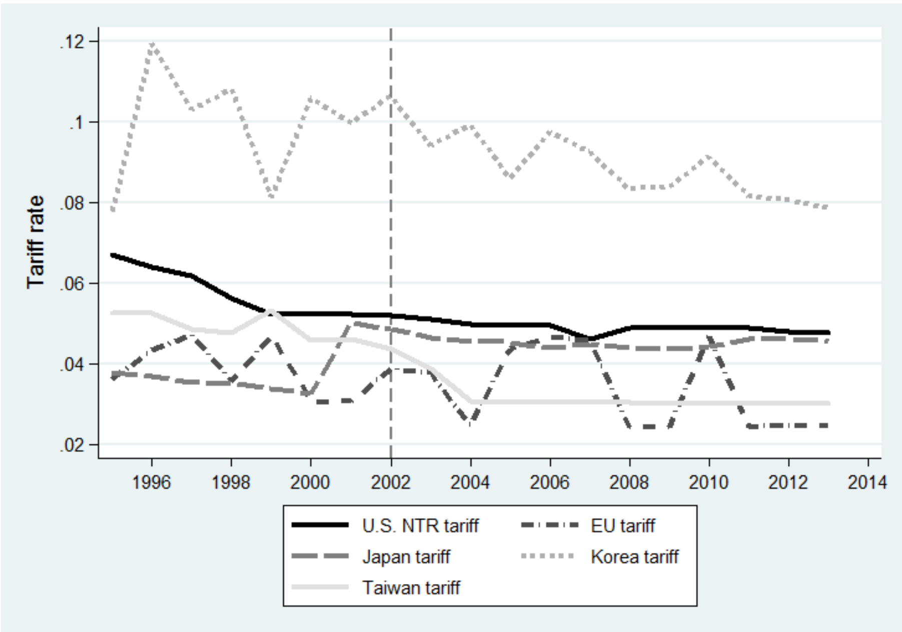
Notes: The first subfigure shows the exports of China to the United States from 1980 to 2015 and the second subfigure shows the total exports of China to all countries from 1981 to 2015. The data for China's exports to the United States is drawn from the IMF Direction of Trade database, and the data for China's total exports is drawn from the FRED database. Both series are deflated to 2009 US dollars using the PCE price index.

Figure 3: Variation in Tariff Policy Over Time

(a) China's Import Tariffs Over Time

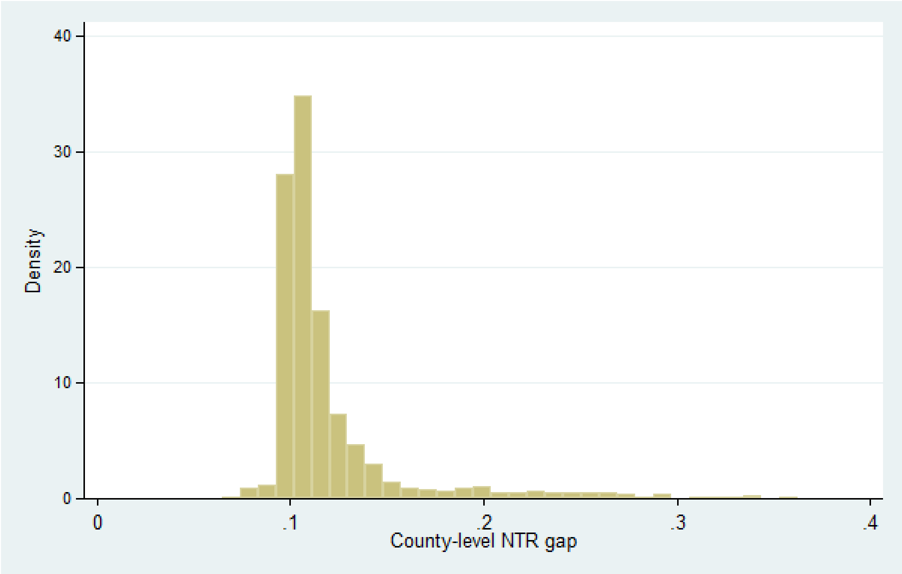


(b) Major Trading Partners' Tariffs Over Time



Notes: The first subfigure shows China's average domestic import tariff, calculated as the weighted average of industry-level tariffs and utilizing as weights the share of total Chinese imports constituted by each industry's imports. The second subfigure shows the mean tariff imposed on Chinese exports by major trading partners from 1996 to 2013. For each trading partner, we again calculate the weighted average of industry-level tariffs, utilizing as weights the share of total Chinese exports constituted by each industry's exports. Tariff data is obtained from the WITS-TRAINS database.

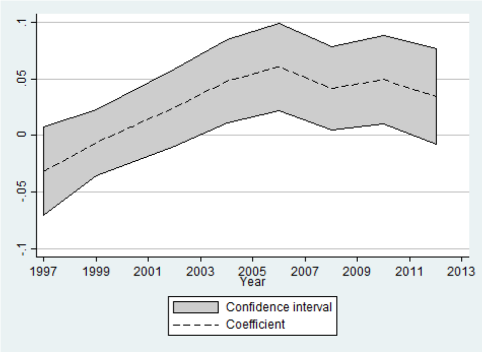
Figure 4: NTR Gap at the County Level



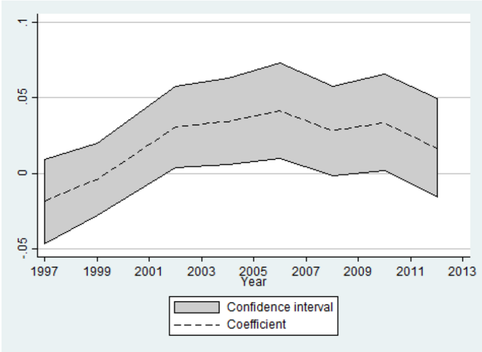
Notes: The figure is a histogram of the gap between normal trade relations (NTR) tariffs and non-NTR tariffs, calculated at the county level utilizing industry employment shares as reported in the 1990 census as weights.

Figure 5: Estimated Dif-in-dif Coefficients and 90% Confidence Intervals

(a) GDP



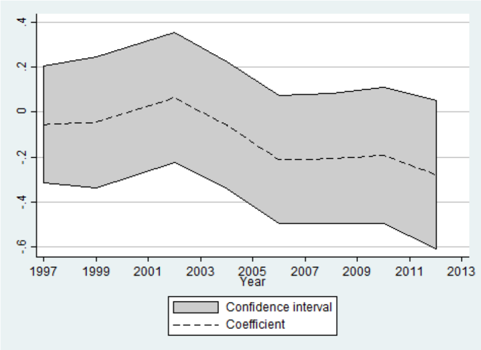
(b) GDP - simple specification



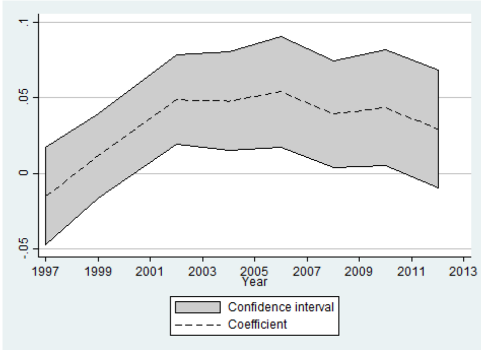
Notes: These graphs report the coefficients on the interaction of dummy variables for each two-year interval and the county-level gap between NTR tariffs and the non-NTR rates, standardized to have mean zero and standard deviation one. The specifications estimated to construct Figure 5a also include a number of control variables: an interaction of the post-reform indicator variable and a time-invariant dummy capturing whether the county is characterized by high contract intensity industries, the industry-weighted MFA quota fill rate for county-produced goods, the industry-weighted national tariff rate for imports of county-produced goods, the industry-weighted percentage of firms licensed to export, and the industry-weighted time-varying NTR rate. Province-year and county fixed effects are included, and the province-year fixed effects are interacted with an urban dummy. The specifications estimated to construct Figure 5b include only the fixed effects of interest. Standard errors are estimated employing clustering at the county level, and the regressions are weighted with respect to baseline county-level employment.

Figure 6: Estimated Dif-in-dif Coefficients and 90% Confidence Intervals: Heterogeneous effects

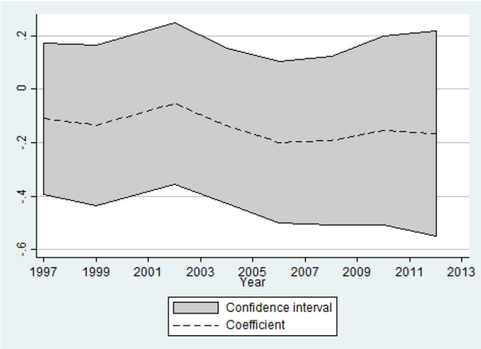
(a) Low capital intensity



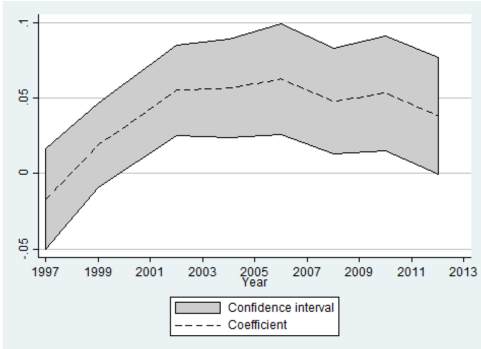
(b) High capital intensity



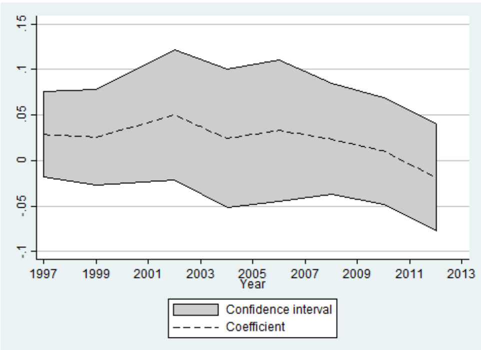
(c) Low U.S. share of exports



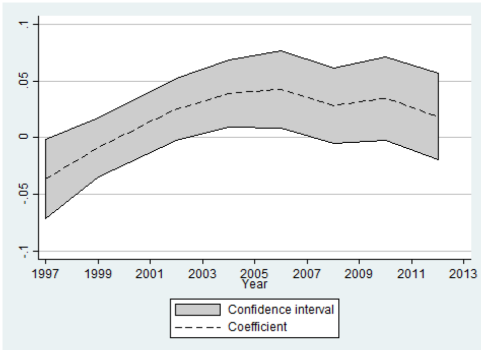
(d) High U.S. share of exports



(e) Low port proximity



(f) High port proximity



Notes: These graphs report the coefficients on the interaction of dummy variables for each two-year interval and the county-level gap between NTR tariffs and the non-NTR rates, standardized to have mean zero and standard deviation one. The specifications estimated include province-year and county fixed effects, and province-year fixed effects interacted with an urban dummy; standard errors are estimated employing clustering at the county level, and the regressions are weighted with respect to baseline county-level employment.

In Figures 6a and 6b, the sample is restricted to counties below and above the median of estimated baseline capital intensity, respectively. In Figures 6c and 6d, the sample is restricted to counties below and above the median estimated baseline share of exports directed to the U.S., respectively. In Figures 6e and 6f, the sample is restricted to counties characterized by low and high port proximity (above and below the median distance between the county centroid and the five major Chinese container ports, respectively).

Table 1: Summary Statistics

Variable	Mean (log)	Mean (level)	Min. (level)	Max. (level)	Obs.	Num. counties
Primary emp.	4.89	181.33	.6	779	3214	354
Ag emp.	4.32	159.94	0	3681	21539	1619
Secondary emp.	3.80	101	.04	1708.53	4523	1235
Tertiary emp.	3.99	86.72	.5	1169.02	4659	1235
Total pop.	5.94	519.67	.8	6850.02	28867	1642
Total emp.	5.26	256.92	3.4	1550.4	19972	1440
Exports	4.93	1184.65	0	190204.6	5337	1017
GDP	7.95	9813.69	.1	611638.25	29782	1688
GDP per capita	8.79	9942.79	0	254907.92	26903	1609
Primary	6.4	1119.97	3.39	18743.66	15673	1496
Secondary	6.88	6937.37	.06	6295413.3	15688	1496
Tertiary	6.74	5979.91	.69	4403172.2	15616	1496
Sown area	3.63	64.76	0	1620.79	8328	989
Agri. machine	2.9	37.76	0	1669.41	28246	1637
Grain output	4.99	247.81	0	5600.1	28277	1627
Cash output	2.91	46.74	0	2377.79	26823	1574
Grain	3.51	56924.16	0	2305598	7169	885

Notes: This table reports the mean in logs, mean in levels, minimum, maximum, number of observations and number of counties reporting any observations for key variables. Total population and employment is reported in thousands of persons. Exports and GDP are reported in millions of yuan and GDP per capita in yuan, deflated to 2000 constant prices. Sown area is reported in thousands of hectares; agricultural machinery power used is reported in 10,000 kilowatts. Grain production and cash crop production are reported in thousands of tons, and grain yield is reported in tons per hectare.

Table 2: Primary Results

	(1)	(2)	(3)	(4)	(5)	(6)
			Panel A: Exports and GDP			
	Exports	Primary	Secondary	Tertiary	GDP	Per capita
Post x NTR gap	.185	.004	.034	.024	.040	.037
	(.083)**	(.018)	(.014)**	(.014)*	(.012)***	(.016)**
Obs.	5158	14722	15688	15375	29782	26332
Num. counties	1017	1496	1496	1496	1688	1609
			Panel B: Employment			
	Primary	Agri.	Secondary	Tertiary	Total emp.	Total pop.
Post x NTR gap	-.048	-.074	.230	.047	-.002	.014
	(.058)	(.026)***	(.107)**	(.125)	(.012)	(.006)**
Obs.	3214	21532	4523	4659	19972	28867
Num. counties	354	1619	1235	1235	1440	1642
			Panel C: Agricultural investment			
	Sown area	Agri. machine	Grain	Cash	Grain yield	
Post x NTR gap	-.040	-.080	-.127	-.049	-.044	
	(.022)*	(.023)***	(.039)***	(.025)**	(.024)*	
Obs.	8322	28149	28161	26818	7168	
Num. counties	989	1637	1627	1574	885	

Notes: The primary independent variable is the interaction of a dummy variable equal to one for the post–2001 period and the county-level gap between NTR tariffs and the non-NTR rates, standardized to have mean zero and standard deviation one. The specification also includes a number of control variables: an interaction of the post-reform indicator variable and a time-invariant dummy capturing whether the county is characterized by high contract intensity industries, the industry-weighted MFA quota fill rate for county-produced goods, the industry-weighted national tariff rate for imports of county-produced goods, the industry-weighted percentage of firms licensed to export, and the industry-weighted time-varying NTR rate. Province-year and county fixed effects are included, and the province-year fixed effects are interacted with an urban dummy. Standard errors are estimated employing clustering at the county level, and the regressions are weighted with respect to baseline employment.

In Panel A, the dependent variables include exports at the county level; primary, secondary, tertiary, and total GDP; and per capita GDP. Exports and GDP are reported in millions of yuan deflated to 2000 constant prices; per capita GDP is reported in yuan, similarly deflated. In Panel B, the dependent variables include employment in the primary, agricultural, secondary, and tertiary sectors, total employment, and population, all reported in thousands of persons. In Panel C, the dependent variables include sown area reported in thousands of hectares, agricultural machinery reported in 10,000 kilowatts, grain and cash crop production reported in thousands of tons, and grain yield reported in tons per hectare. All dependent variables are logged. Asterisks indicate significance at the ten, five, and one percent level.

Table 3: Robustness Checks

	Exports (1)	Primary (2)	Secondary (3)	Tertiary (4)	GDP (5)	Per capita (6)
Panel A: NTR gaps estimated using 2000 employment weights						
Post x NTR gap	.111	-.019	.041	.039	.040	.036
	(.051)**	(.012)	(.013)***	(.011)***	(.010)***	(.011)***
Obs.	5158	14690	15646	15340	29740	26318
Panel B: NTR gaps estimated assigning non-tradables zero weights						
Post x NTR gap	.088	-.056	.003	-.009	.024	.020
	(.049)*	(.019)***	(.014)	(.010)	(.009)**	(.009)**
Obs.	5158	14722	15688	15375	29782	26347
Panel C: Main specification controlling for the share of non-primary employment						
Post x NTR gap	.209	.006	.026	.023	.032	.010
	(.085)**	(.020)	(.015)*	(.014)	(.012)***	(.015)
Obs.	5158	14722	15688	15375	29782	26347
Panel D: Main specification controlling for the share of high gap employment						
Post x NTR gap	.212	.010	.032	.024	.041	.020
	(.081)***	(.020)	(.015)**	(.014)*	(.012)***	(.015)
Obs.	5158	14722	15688	15375	29782	26347
Panel E: Main specification controlling for pre-trends in employment						
Post x NTR gap	.196	-.011	.042	.021	.033	.011
	(.082)**	(.018)	(.016)***	(.013)	(.013)**	(.018)
Obs.	5158	14706	15672	15359	29766	26365

Notes: The primary independent variable is the interaction of a dummy variable equal to one for the post–2001 period and the county-level gap between NTR tariffs and the non-NTR rates, standardized to have mean zero and standard deviation one. The specification also includes a number of control variables: an interaction of the post-reform indicator variable and a time-invariant dummy capturing whether the county is characterized by high contract intensity industries, the industry-weighted MFA quota fill rate for county-produced goods, the industry-weighted national tariff rate for imports of county-produced good, the industry-weighted percentage of firms licensed to export, and the industry-weighted time-varying NTR rate. Province-year and county fixed effects are included, and the province-year fixed effects are interacted with an urban dummy. Standard errors are estimated employing clustering at the county level, and the regressions are weighted with respect to baseline employment. The dependent variables are exports at the county level; primary, secondary, tertiary, and total GDP; and per capita GDP. All dependent variables are logged.

In Panel A, the NTR gap at the county level is estimated using employment weights from the 2000 census. In Panel B, the NTR gap is estimated using employment weights from the 1990 census and assigning the services or non-tradable sector a zero weight. In Panel C, the specification includes a full set of interactions between dummies for quartiles of initial secondary and tertiary employment as a fraction of total employment and year fixed effects. In Panel D, the specification includes a full set of interactions between dummies for quartiles of employment in each of five high NTR gap industries as a fraction of total employment and year fixed effects. In Panel E, additional control variables are added for the long-difference in primary and non-primary employment between 1990 and 2000 (as reported in the census) interacted with a post dummy. Asterisks indicate significance at the ten, five, and one percent level.

Table 4: Evidence around timing

	GDP							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NTR gap x 97-98	-.031	-.018	-.056	-.015	-.110	-.017	.004	-.030
	(.024)	(.017)	(.159)	(.020)	(.173)	(.020)	(.019)	(.029)
NTR gap x 99-01	-.006	-.004	-.046	.012	-.135	.019	.023	.003
	(.018)	(.014)	(.178)	(.017)	(.183)	(.017)	(.018)	(.022)
NTR gap x 02-03	.025	.031	.065	.049	-.054	.055	.005	.050
	(.021)	(.016)*	(.176)	(.018)***	(.185)	(.018)***	(.023)	(.023)**
NTR gap x 04-05	.048	.034	-.060	.048	-.137	.056	-.006	.055
	(.023)**	(.017)**	(.171)	(.020)**	(.178)	(.020)***	(.024)	(.024)**
NTR gap x 06-07	.060	.041	-.212	.054	-.200	.062	-.020	.068
	(.023)***	(.019)**	(.173)	(.022)**	(.184)	(.022)***	(.027)	(.025)***
NTR gap x 08-09	.042	.028	-.208	.039	-.192	.048	-.019	.052
	(.022)*	(.018)	(.176)	(.021)*	(.192)	(.021)**	(.026)	(.025)**
NTR gap x 10-11	.049	.034	-.193	.043	-.154	.053	-.026	.063
	(.024)**	(.020)*	(.185)	(.023)*	(.215)	(.023)**	(.024)	(.026)**
NTR gap x 12-13	.034	.017	-.279	.029	-.167	.038	-.047	.052
	(.026)	(.020)	(.202)	(.024)	(.234)	(.024)	(.025)*	(.028)*
Sample	Full		Low cap. int.	High cap. int.	Low U.S. share	High U.S. share	Low port prox.	High port prox.
Additional controls	Yes	No	No	No	No	No	No	No
Obs.	29782	30390	15892	14498	15902	14488	15200	15002

Notes: The primary independent variable is the interaction of the county-level gap between NTR tariffs and the non-NTR rates, standardized to have mean zero and standard deviation one, and a series of dummy variables capturing two-year intervals. The dependent variable is the log of county-level GDP. Standard errors are estimated employing clustering at the county level, and the regressions are weighted with respect to baseline employment.

In Column (1), the specification also includes a number of control variables: an interaction of the post-reform indicator variable and a time-invariant dummy capturing whether the county is characterized by high contract intensity industries, the industry-weighted MFA quota fill rate for county-produced goods, the industry-weighted national tariff rate for imports of county-produced goods, the industry-weighted percentage of firms licensed to export, and the industry-weighted time-varying NTR rate. Province-year and county fixed effects are included, and the province-year fixed effects are interacted with an urban dummy. Column (2) includes only county and province-year fixed effects, and province-year fixed effects interacted with an urban dummy.

In Columns (3) through (6), again the specifications include only county and province-year fixed effects, and province-year fixed effects interacted with an urban dummy. Column (3) reports the results for counties below the median of baseline capital intensity in non-state owned enterprises; Column (4) reports the results for counties above median baseline capital intensity for non-SOEs. Column (5) reports the results for counties below the median of baseline U.S. share of total exports; Column (6) reports the results for counties above median U.S. export share. Column (7) reports the results for counties characterized by low port proximity, or above the median of average distance to the five largest ports; Column (8) reports the results for counties characterized by high port proximity, or below the median of average distance. Asterisks indicate significance at the ten, five, and one percent level.

Table 5: Factor utilization and other firm outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A: Factor utilization					
	Emp.	Capital	Foreign capital	Cap. intensity	Wages	Wages per worker
Post x NTR gap	.062	.119	.166	.006	.092	.066
	(.035)*	(.044)***	(.048)***	(.066)	(.037)**	(.028)**
Obs.	2492	2515	2496	2515	2515	2492
	Panel B: Other firm outcomes					
	Sales	Value added	Profits	Value added per worker		
Post x NTR gap	.089	.154	.125	.122		
	(.035)**	(.057)***	(.100)	(.054)**		
Obs.	2515	2262	2061	2247		

Notes: The primary independent variable is the interaction of a dummy variable equal to one for the post–2001 period and the prefecture-level gap between NTR tariffs and the non-NTR rates, standardized to have mean zero and standard deviation one. The specification includes the same control variables described in the notes to Table 2, all calculated as the average at the prefecture-year level, as well as the NTR gap at the prefecture level entering linearly, and province-year fixed effects and prefecture-specific trends. Standard errors are estimated employing clustering at the prefecture level.

All dependent variables are logged. The dependent variables in Panel A include total employment in sampled firms, total capital in sampled firms, total foreign capital in sampled firms, the total wage bill in sampled firms, and mean wage per worker. The dependent variables in Panel B include total exports, sales, value added and profits in sampled firms, as well as mean value added per worker. Asterisks indicate significance at the ten, five, and one percent level.