A Dynamic Quantitative Analysis of Labor Market Implications of Taiwan's WTO Accession: Skill, Capital, and the China Shock*

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Abstract

This paper studies the impacts of Taiwan's accession to the WTO in 2002 on the labor market dynamics in Taiwan during 1995-2020. Our quantitative framework incorporates skill transition and capital accumulation into a dynamic open-economy, general-equilibrium labor market model. The quantitative analysis suggests that tariff reductions during this period help explain the phenomenal expansion of key manufacturing sectors, increasing shares of high-skilled labor, and the uneven capital accumulation across sectors in Taiwan. Skill upgrade, capital accumulation, and bilateral tariff concessions with respect to China played significant roles in Taiwan's dynamic adjustments to its WTO accession quantitatively and qualitatively.

Key Words: Labor Market Dynamics; Mobility Frictions; Skill Upgrade; Capital Accumulation; Skill-Capital Complementarity

JEL Classification: F13; F14; F16; F17

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1 Introduction

The trade literature has extensively studied the labor-market and welfare effects of trade liberalization and large external shocks. A substantial body of research has examined the "China shock" on large economies such as the US, focusing on its overall impact and its heterogeneous effects across regions and sectors (e.g., Caliendo, Dvorkin and Parro, 2019; Adão, Arkolakis and Esposito, 2021; Autor, Dorn and Hanson, 2013, 2021). In this paper, we focus on Taiwan to highlight the importance of contexts for the study of labor market adjustments to a large-scale external shock. Specifically, we investigate the effects of Taiwan's accession to the WTO in January 2002 on Taiwan's labor market outcomes. Because China entered the WTO around the same time, the two economies became much more open to each other through the WTO platform, and consequently, the China shock also affected the Taiwanese economy and its labor markets.

Taiwan is an interesting case for several reasons. First, it is a small open economy that is geographically close to China. Therefore, it may have experienced much greater impacts of the China shock than distant/large economies. Second, during the period studied, Taiwan was more developed than China but less than the US. In terms of structural change and comparative advantages, China's rise may have posed greater and more immediate challenges to the manufacturing industries in Taiwan. How did the Taiwanese economy respond to the challenges and opportunities? Third, Taiwan saw swift changes in its skill compositions during the period of WTO accession, transforming into a highly skill-abundant economy relative to China and much of the rest of the world. Related to the second point, how did these changes in skill composition play a part in Taiwan's response to the rise of China? At this writing, the tension between China and Taiwan and that between China and the US are both at historical high points. Understanding how the Taiwanese economy has become so intertwined with China's and how the China shock for Taiwan differs from that for the US are of paramount academic and policy interests.

The journey of Taiwan's accession to the GATT/WTO started when it formally applied for GATT membership in 1990. It became an observer in 1992 and finally entered the WTO in January 2002, shortly after China joined in December 2001. The tariff reductions associated with this event took place during a long period (from the mid-1990s to the late 2000s). We start by documenting seven stylized facts on Taiwan's tariffs, trade patterns, labor markets, and capital accumulation during 1995–2007. First, Taiwan reduced its import tariffs relatively more in the primary sector (agriculture and mining), while foreign tariffs against Taiwan's exports dropped comparatively more in the manufacturing sectors. Second, China overtook the US and became the leading trading partner of Taiwan. Third, two manufacturing sectors, “Machinery, Computer, Electronics & Electrical Machinery” (hereafter MCEE) and “Petroleum, Chemicals, Plastics, Metals” (hereafter PCPM), stood out as the engines of growth of Taiwanese exports during this period. Fourth, the export growth of the MCEE sector was predominantly driven by exports to China. Fifth, we observe a salient trend of worker transition out of the primary and labor-intensive manufacturing sectors and into the MCEE and some service sectors. Sixth, the high-skilled labor shares in the economy increased substantially (from 17.4% in 1995 to 34.7% in 2007), and the increase was most significant in the MCEE and Business Services sectors. Seventh, the capital stock grew by 67% during this period, driven by disproportionately faster growth in the MCEE and key service sectors.

The above stylized facts highlight significant shifts in the production and trade structure of Taiwan, during a period with major trade liberalization (including Taiwan’s own WTO accession and also that of China), facilitated by possibly skill upgrading and capital accumulation. Specifically, increased trade openness—particularly with China—has led Taiwan to specialize more in its comparative advantage sectors (MCEE and PCPM). The expansions of these star sectors (being both skill- and capital-intensive) are consistent with the observed supply-side responses in skill upgrading and capital accumulation, and the sectoral reallocation of productive factors toward these sectors. In addition, the growth in skill employment and capital stock in some service sectors underscores the importance of input-output linkages.

To evaluate the impacts of tariff reductions, and the contribution of competing mechanisms (the roles of China, skill upgrading, and capital accumulation), we develop a quantitative framework that builds on the dynamic open-economy model of Caliendo, Dvorkin and Parro (2019, henceforth CDP) and allows for skill upgrading, capital accumulation, and skill-capital complementarity. Specifically, the production in each sector uses capital and three types of skills (low, middle, and high), whose factor intensities are endogenously determined, given factor prices and elasticities of substitution across factors. Workers in the local economy make dynamic sector-skill choices in each period in response to sector-skill-specific wages, goods prices, sector-skill switching costs and idiosyncratic preference shocks. The dynamics of capital accumulation is determined by the capital owners who face a consumption-investment tradeoff, whereas capital allocation across sectors is pinned down by sector production and skill allocations given skill-capital complementarity.

The model is calibrated to 60 economies and a residual Rest-of-World, 22 sectors (primary, 11 manufacturing sectors, and 10 service sectors) plus non-employment, workers of three skill types, and capital. We compile data on Taiwanese labor market dynamics during 1995–2007, together with data on tariffs, trade flows, input-output linkages, skill compositions, and capital stocks for these economies and sectors. In particular, we obtain information on Taiwanese workers' transition across sectors and skills in each year during the period 1995–2007 based on *Manpower Utilization Quasi-longitudinal Data* of Taiwan. Following the approach of Artuç and McLaren (2015), we estimate the sector-skill transition elasticity that is required for the counterfactual analysis, along with the transition costs of skill-upgrading and sector-switching that characterize the Taiwanese labor markets.

Using the calibrated model, we first simulate a baseline economy (in terms of changes over time) that reflects factual unobserved time-varying fundamentals for the data period 1995–2007, and with constant fundamentals afterwards (up to a specified simulation terminal period). To study the effect of Taiwan's WTO accession, we then simulate a counterfactual economy in which all the Taiwan-related tariffs (Taiwanese tariffs on imports and foreign tariffs on Taiwanese exports) are rolled back to their levels in 1995. The comparison of such a counterfactual economy with the baseline economy (which incorporates factual changes in fundamentals, including tariffs) reveals the effect of Taiwan's WTO accession on the Taiwanese economy and labor markets. We simulate the transition dynamics for a sufficiently long time period (for the effects of the trade shocks to reach steady states) and report the effects on labor markets, capital dynamics, and welfare for the period 1995–2020.

The counterfactual analysis delivers a rich set of results. We find that Taiwan's accession to the WTO induced a decline in the primary sector's employment, accounting for 10.0% of this sector's labor force in 1995. Meanwhile, the manufacturing sector saw an increase in employment share by 6.1% of the population (which is a 29.6% increase from its initial employment share at 20.6%). The effect on the service sector is much more muted: a decrease of 1.4% in terms of employment share (corresponding to a 3% decrease from its initial employment share at 45.2%). These changes are one order of magnitude larger than those reported in CDP (around $\pm 0.3\%$), which can be attributed to the export-oriented, small-and-open nature of the Taiwanese economy. Among manufacturing sectors, the growth of the employment shares is particularly pronounced in the MCEE sector. These are consistent with the stylized facts. Although various compounding factors may have contributed to the stylized facts, our analysis indicates that Taiwan's accession to the WTO played a significant role in shaping the observed patterns.

When these broad sectoral-level changes are further disaggregated by skill groups, we find that most of the labor outflow from the primary sector was by low-skilled workers. In contrast, the manufacturing sectors experienced employment growth across skill levels, with a trend toward skill upgrading. The skill upgrade was most pronounced in the MCEE sector, as it absorbed disproportionately larger shares of high-skilled workers. A similar trend of skill upgrading was also observed in the service sectors. Overall, the sectors with larger employment gains also underwent larger degrees of skill upgrading. These model-simulated effects of Taiwan's WTO accession on skill compositions are aligned with the stylized facts.

In the aggregate, Taiwanese workers experienced a 3.1% welfare gain for the period 1995–2020 due to the WTO entry. This magnitude is large in comparison with findings in the literature that use similar analytical frameworks for large economies (Caliendo, Dvorkin and Parro, 2019; Caliendo, Parro, Opromolla and Sforza, 2021). Most importantly, the welfare effects are heterogeneous across sectors and skills. The welfare gains for low-, middle-, and high-skilled workers are 2.27%, 2.75%, and 4.63%, respectively. By sector, Taiwan's WTO entry resulted in the largest welfare gains for workers in manufacturing (3.45%), followed by services (3.08%) and the primary sector (2.59%).

We examine the role of China by conducting alternative counterfactuals where subsets of the factual tariffs are reverted to their 1995 levels. For example, to evaluate the effects of bilateral tariff concessions between Taiwan and China, (only) the two economies' tariffs imposed against each other's exports are returned to their 1995 levels in the counterfactual. Alternatively, to evaluate the combined effects of WTO accession by Taiwan and China, both Taiwan's and China's import tariffs and foreign tariffs on Taiwan's and China's exports are set to their levels in 1995 in the counterfactual. We find that most of the labor-market impacts observed in the benchmark (Taiwan's WTO accession) were driven by the bilateral tariff concessions between Taiwan and China. Compared with bilateral tariff concessions, Taiwan's WTO accession (i.e., multilateral liberalization) strengthened the quantitative impacts. However, further multilateral liberalization by China's WTO accession dampened the positive effects for manufacturing sectors and higher-skilled workers in Taiwan (as this created a "competition effect" for Taiwanese exports in third countries and in China's local market). Nonetheless, our analysis suggests that the China trade shock created a net positive employment effect for the Taiwanese manufacturing sector, in drastic contrast with the existing literature that typically finds the China shock to hurt manufacturing jobs in other economies.

We further examine the role of skill upgrading and capital accumulation in explaining the effect of Taiwan's WTO accession. We find that the employment effects of Taiwan's WTO accession are much smaller in the absence of skill upgrading. This suggests the existence of strong complementarity between skill upgrading and tariff concessions during the period studied. Essentially, the skill-upgrade mechanism allowed the supply side to respond to the increased demand for higher skills (as Taiwan re-oriented its sectoral specialization toward MCEE and PCPM) and helped mitigate the upward pressure on skill premiums. The increased supply of skilled labor also spilled over into the service industries and the other manufacturing industries. As a result, we observe significantly larger responses in employment across sectors, and less income redistribution effects across skills. In sum, eliminating the skill-upgrade mechanism would substantially underestimate the workers' welfare gains from Taiwan's WTO entry. Finally, our quantitative analysis indicates that Taiwan's WTO entry substantially accelerated capital accumulation in both manufacturing and services, and much more so in manufacturing. It also suggests that capital accumulation amplified the high-skilled employment share in manufacturing while dampened that in services, enlarging the welfare gains for the high-skilled workers relative to the other workers.

Related Literature

This paper contributes to several strands of the existing literature. First, it is closely related to studies on dynamic labor-market adjustments across different "categories" in open-economy environments. Such categories can be occupations, sectors, regions, etc. For some prominent examples, see Caliendo, Dvorkin and Parro (2019), Artuç, Chaudhuri and McLaren (2010), Artuç and McLaren (2015), and Caliendo, Parro, Opromolla and Sforza (2021). This paper is also closely related to a set of studies on labor-market adjustments in static environments, including Lee and Yi (2018), He (2019), Tombe and Zhu (2019), Burstein, Hanson, Tian and Vogel (2020), Kim and Vogel (2020), Lee (2020), Adão, Arkolakis and Esposito (2021), and Kim and Vogel (2021). Our work differs by allowing for skill upgrading and capital accumulation (with skill-capital complementarity), which are key to Taiwan's adjustment during the study period.

Second, our paper is related to the literature on how trade liberalization influences skill acquisition and skill premiums; see, e.g., Greenland and Lopresti (2016), Atkin (2016), Blanchard and Olney (2017), and Li (2018). These papers provide empirical evidence that trade-driven demand shocks can influence human capital investment decisions and the skill supply of a country, across countries, or across regions within a country. Our work complements these studies by revisiting the issue with the toolkits of dynamic labor market models (Artuç, Chaudhuri and McLaren, 2010) and dynamic hat algebras (Caliendo, Dvorkin and Parro, 2019; Caliendo and Parro, 2020).

Third, our study is related to the empirical literature on the impacts of the China shock. This includes the seminal studies of Autor, Dorn and Hanson (2013), Acemoglu, Autor, Dorn, Hanson and Price (2016), Bloom, Handley, Kurman and Luck (2019), Feenstra, Ma and Xu (2019), and Autor, Dorn and Hanson (2021). While these works found largely negative impacts of the China shock on the US labor market, our study highlights how Taiwan (given its unique sectoral specialization, swift skill upgrading, and capital accumulation) may respond to the China shock differently from the US.

The rest of the paper is organized as follows. Section 2 presents a set of key stylized facts on Taiwan's trade patterns, labor market and capital dynamics. Section 3 outlines the quantitative framework. Section 4 estimates key labor-market parameters and calibrates the model. Section 5 presents the quantitative dynamic impacts of Taiwan's WTO accession. Section 6 further examines the roles of China, the skill-upgrade mechanism, and capital accumulation in explaining Taiwan's adjustments to its WTO accession. Section 7 concludes. Additional documentations, proofs, and analyses are provided in the appendix following the text, and in Online Appendix.[1]

2 Stylized Facts

In this section, we characterize Taiwan's structures of tariffs, trade, labor markets, and capital dynamics. Taiwan applied for GATT membership in 1990, and became an observer in 1992. Its average tariff was modest in 1990, at 9.7%. This was due to a long history of bilateral trade talks with the US since 1959. Nevertheless, to become a member of GATT/WTO, Taiwan negotiated with the other member countries, and this led to further reductions in its tariffs, many of which took effect after Taiwan became a formal WTO member. Taiwan joined the WTO in January 2002, right after China's accession in December 2001. We collect data for the period 1995–2007, which spans seven years before and six years after its accession to the WTO. This period is also the time when China undertook substantial trade liberalization (unilaterally before its WTO entry and multilaterally afterward). Taiwan's close proximity to China in geography and historical ties, as well as its relatively small size, suggest that the effects on trade and labor markets that Taiwan sustained would be heavily influenced by the Chinese economy. We study how Taiwan's WTO entry and trade liberalization during this period reshaped its labor markets, against the backdrop of China's integration into the world economy.

For characterization of stylized facts, we use data from mainly three sources. First, the tariff data were downloaded at the HS 6-digit level from the World Integrated Trade Solution (WITS) database for the years 1995–2007 and aggregated to the sectoral definition for stylized facts using the WITS trade value as weights. Second, we extracted the Taiwanese international trade data from the OECD TiVA ICIO Tables (2016 edition). In particular, we deflate Taiwanese exports and imports by the corresponding "export price index" and "import price index" in each year, so that all trade flows are converted to the 1995 price level in USD. The export and import price indices are obtained from the Taiwanese Direc-

[1] Available at Pao-Li's website: `http://www.mysmu.edu/faculty/plchang/`, or Wen-Tai's: `http://wthsu.com`.

torate General of Budget, Accounting and Statistics (DGBAS). Third, for the Taiwanese labor statistics, we used the *Manpower Utilization Quasi-longitudinal Data* from the Survey Research Data Archive (SRDA) of Academia Sinica, Taiwan.

We also document Taiwan's capital stock allocation across sectors, based on *Industry, Commerce and Service Census of Taiwan* from DGBAS, with the nominal value converted to the 1995 price level using the GDP deflator from DGBAS. Note that the sectoral-level capital stock data are only available in every 5 years during the period of study, and are missing for agriculture. Thus, this set of data is presented solely for the characterization of stylized facts. For the quantitative simulation analysis below, we will use the economy-level aggregate capital stock data, and let the model determine the capital allocation across sectors in each economy.

2.1 Patterns of Tariff Changes

We first document how the Taiwanese tariffs on imports and foreign tariffs on Taiwanese exports changed in the primary and manufacturing sectors during this period.

Fact 1: Taiwanese import tariffs fell relatively more in the primary sector, while foreign tariffs against Taiwanese exports fell relatively more in the manufacturing sector.

In Table 1, we report the changes (in percentage points) of average tariffs (across products and trading partners of Taiwan) in the primary and manufacturing sectors, before and after its accession to the WTO. The primary sector includes broadly-defined agriculture (inclusive of livestock, forestry, and fishing) and mining. During 1995–2001, foreign economies reduced tariffs on Taiwanese manufacture exports (by -2.54%) while increasing tariffs on its primary exports (by 0.07%). Meanwhile, Taiwanese import tariffs decreased, and relatively more in manufacturing than in the primary sector. After its accession to the WTO, Taiwan further decreased its import tariffs during 2002–2007, much more so in the primary sector (-4.42%) than in manufacturing (-1.31%). Foreign economies reciprocated and further reduced their tariffs on Taiwanese exports, similarly more so in the primary sector (-3.10%) than in manufacturing (-1.75%). Combining the changes across the two periods, Taiwan reduced tariffs in the primary sector (-4.84%) by more than its trading partners reduced tariffs on Taiwanese exports in this sector (-3.03%). The reverse is true for manufacturing: the foreign economies reduced tariffs on Taiwan's exports of manufactures (-4.29%) by more than Taiwan's tariff reduction in manufactures (-2.56%). Thus, overall, Taiwan liberalized its primary sector in exchange for access to foreign markets in the manufacturing sector.

Although the mean tariff changes reported in Table 1 are small, there is a large degree of heterogeneity at the tariff line level. We plot the tariff changes (in percentage points) at the HS 6-digit level from 1995 to 2007 in Figure 1. While the previous stylized fact indicates that average tariff changes are in the range of -4.42% to 0.07%, this figure shows that changes at the disaggregated product level are very dispersed. On the import side, most of the product lines saw a reduction in tariffs, and the tariff changes could be as large as -20%. Meanwhile, tariffs on Taiwanese exports did not uniformly decrease. A non-negligible share of Taiwanese products faced an increase (instead of a decrease) in foreign tariffs; in contrast, certain products that Taiwan exported saw significant tariff reductions of more than 20%.

2.2 Trade Patterns

During this period, Taiwanese trade with the world increased drastically by 127.0%, while its domestic trade share dropped from 76.5% to 67.4%. We investigate the changes in the patterns of trade underlying such phenomenal growth in overall trade volume.

Fact 2: China overtook the US and became the leading trading partner of Taiwan.

In Figure 2, we plot the trade share of Taiwan with its major trading partners, including itself, during 1995–2007. Taiwan's import share rose from 23.5% to 32.6% during 1995–2007, whereas its export share rose from 22.0% to 33.7%. In 1995, the US was the largest trading partner of Taiwan when combining exports and imports. By the end of 2007, China had risen to become Taiwan's largest export destination and its second largest import origin (behind Japan).[2] The overall trade volume (exports plus imports) with China exceeded that of any other trading partners of Taiwan since 2002.

Figure 3 illustrates the changes in trade volumes at the sector level. Two sectors, "Machinery, Computer, Electronics & Electrical Machinery" (MCEE) and "Petroleum, Chemicals, Plastics, Metals" (PCPM), emerged to be particularly important in accounting for the changes in the patterns of trade.

Fact 3: The MCEE and PCPM sectors were the engines of growth of Taiwanese exports.

It is clear from Figure 3 that these two sectors are relatively large in terms of both exports and imports, compared with the other sectors. Moreover, both sectors saw substantial growth in trade over this period, and especially so in their exports. Table 2 provides the detailed statistics and breakdown of Taiwan's exports/imports across sectors in 1995 and 2007, the growth rate of exports/imports by sector between 1995 and 2007, and each sector's

[2]The import share from Japan decreased slightly during the period while that of China rose substantially. In recent years, China has become the largest import origin of Taiwan.

contribution to the overall increase of Taiwan's exports/imports during this period. First, note that the MCEE sector was the largest among all sectors in 1995, with its exports accounting for 37.5% of Taiwan's total exports in that year. While Taiwan's total exports increased by 166.2% during this period, MCEE' exports grew by 216.7%, outpacing the economy's export growth rate by a wide margin. As a result, this sector's export share grew sharply to reach 44.6% in 2007. Given its large base, MCEE also accounted for the largest share (48.9%) of Taiwan's exports increase during this period. The PCPM sector is important for Taiwanese exports in a similar way. The sector's exports grew at an even faster rate (278.5%) than MCEE, enlarging its export share in the economy from 18.4% to 26.1% during the period. As a result, the sector contributed to 30.8% of the economy's overall increase in exports, second only to MCEE. In short, the growth of Taiwanese exports during this period has been driven by the MCEE and PCPM sectors.

On the imports side, three sectors stood out. The MCEE and PCPM sectors continued to dominate in terms of their contributions to the overall economy's imports growth, although to a lesser extent than in terms of exports. They are followed by the primary sector, which accounted for 24% of the economy's import growth during this period. Specifically, the primary sector's imports grew at a rate of 296.9% (faster than those of PCPM and MCEE) such that its import share grew from 7% to 14.9% during this period. Within the primary sector, import growth rates in both agriculture and mining sectors were large, but mining's contribution toward the overall economy's import growth outweighed agriculture's. This was partly due to the fact that mining was closely tied to the PCPM sector, where the former provides the raw materials (such as crude oil and raw metals) required in the latter's production but which Taiwan is not well endowed with.

Note that even though agriculture's import growth did not contribute significantly to Taiwan's overall import growth, its sharp import growth rate (80.1%, not reported in the table) could still have substantial impacts on the local labor markets, because it accounted for most of the employment in the primary sector. We will revisit this issue in Section 2.3.

Fact 4: MCEE export growth was predominantly driven by exports to China. PCPM export growth could be attributed to a number of destination markets, with China taking a leading role.

In light of Fact 3, we further break down trade in the MCEE and PCPM sectors by country of origin and destination. Figure 4 illustrates the trade pattern for each year in the period 1995–2007. Tables 3 and 4 tabulate, for the MCEE and PCPM sectors respectively, the shares of exports/imports accounted for by each destination/origin, the growth rates of exports/imports to/from each destination/origin, and each destination/origin's relative contribution to the overall increase in exports/imports in each of these sectors between 1995 and 2007.

In the MCEE sector, Taiwan's exports to China grew drastically by 1781.6%, raising China's share in total MCEE exports from 8.2% to 48.5%. Correspondingly, China has contributed to 67.2% of the overall increase in Taiwan's MCEE exports; this is in contrast with single-digit percentage contribution by all the other destinations. China as an import origin in the MCEE sector also grew in importance from 1.4% to 21.1%, and contributed to 40.4% of the increase in MCEE imports (outweighing all the other origins). Note that the initial total MCEE exports were about 50% larger than imports (46,060 vs. 30,271 in 1995 million USD), and the export growth (216.7%) outpaced the import growth (102.1%) by a wide margin. Together with the predominant role of China in Taiwan's MCEE export growth documented above, these observations underscore China's potential impacts on Taiwan's trade and economy.

In the PCPM sector, while the initial total exports were slightly lower than the initial total imports (22,598 vs. 27,540 in 1995 million USD), exports grew much faster than imports (278.5% vs. 106.3%), such that by 2007 exports had exceeded imports. China, again, stood out to be the most important export destination, contributing to 40.3% of the export growth in this sector. Several other destinations, however, were also important. In particular, Indo-Pacific (the ASEAN countries plus India, Australia, and New Zealand), the US, and the ROW contributed to 15.9%, 11.0%, and 14.8% of the overall PCPM export growth, respectively. Finally, on PCPM imports, China's dominance is much more reduced relative to its role in Taiwan's MCEE exports/imports and PCPM exports.

These changes in trade patterns as documented above could have had profound implications for factor demand, in particular for the labor transition across sectors and the skill distribution in Taiwan. We now provide stylized facts with regard to the Taiwanese labor market and capital dynamics during this period.

2.3 Patterns of Labor Transition and Capital Dynamics

Table 5 summarizes the pattern of labor transition across sectors in Taiwan during the period 1995–2007. We calculate the proportion of workers from an origin sector in a year that chose to switch to a destination sector in the following year. The number in each cell in the table measures the average transition rate across years from an origin sector (along a row) to a destination sector (along a column). The top five destination sectors for each origin sector are highlighted. In particular, the cells that are highlighted in blue denote the proportions of worker that chose to stay in the same sector, while those highlighted in yellow denote the top four destinations other than the origin sector. The last four columns of the table report the average years of schooling of workers in each sector, the sectoral employment shares (measured in terms of shares of total employment plus non-employment) in 1995 and 2007, and the change in the sectoral employment share from 1995 to 2007 in percentage points.

Fact 5: Labor transitioned out of the primary and labor-intensive manufacturing sectors and into the MCEE and service sectors.

Several patterns in the table are noteworthy. First, the primary sector suffered a large drop in its employment share (by 5.3 percentage points from 9.3% to 3.9%). Of this drop, 5.2 percentage points were due to agriculture, as mining employment in Taiwan was negligible. Even though the primary sector's production is dwarfed by the other sectors, it accommodated a relatively large number of workers in Taiwan (9.3% in 1995). Entering the WTO was a political goal of the then Taiwanese government for various reasons, but it faced major objections from farmers. How to compensate the agricultural sector was a contentious political issue for the government at the time. The sharp drop in the sector's employment share validated farmers' concerns. The negative employment shock to the primary sector is also reflected by the fact that on average and in each year, 5.2% of its labor was displaced from the sector and did not find an alternative job. These labor market responses could be attributed to the increased import competition in the sector during this period, as documented in the previous subsections. The labor displacement effect could be further exacerbated by the fact that the transition cost for peasants to switch to alternative sectors of employment is likely higher than workers from the other sectors, because this sector's general skill level (i.e., years of schooling) is the lowest among all sectors, and the sector-specific human capital in this sector does not easily transfer to jobs in the other sectors.

Second, in addition to the primary sector, workers also tended to move out of the manufacturing sectors except the MCEE. Comparison of the diagonal cells in blue from the top left quadrant (i.e., the primary and manufacturing sectors) with the diagonal cells in blue from the bottom right quadrant (i.e., the service sectors) reveals that the numbers reported for the manufacturing sectors are in general lower than for the service sectors. Thus, smaller fractions of workers in the manufacturing sectors stayed in the same sectors than workers in the service sectors. In particular, workers in Taiwan tended to move out of sectors in which Taiwan was losing comparative advantage, e.g., textiles, wood, and paper. These sectors either faced rising foreign competition or became less attractive in comparison with the sectors that were expanding (which we document next).

Third, workers were observed to move into the MCEE, PCPM, and service sectors. This is evident from the yellow cells, which represent the top destination sectors for each origin sector (other than the origin itself). All but three yellow cells are to these sectors. The fact that the MCEE and PCPM sectors received labor inflow from other sectors is consistent with the trade patterns documented above. However, PCPM also experienced a large labor outflow (close to 20% of its workers on average) and hence only a small net increase in its employment share (+0.2%) during the period 1995–2007. This likely reflected the sector's structural change over the years, when its production became more capital-intensive (which displaced workers) and skill-intensive (which attracted new workers with higher skill levels).

To understand the general movement from manufacturing to service sectors, note that this structural transformation often accompanies the process of economic development, and this might explain part of the observed movement from manufacturing to service sectors in the case of Taiwan. But what might be more important is the fact that manufacturing sectors in general faced fierce competition from China during this period, especially in labor-intensive sectors. Anecdotal evidence suggests that the manufacturing sectors in Taiwan saw many firm exits during this period. Some of the displaced workers went to the MCEE and PCPM sectors, but many more of them went to the service sectors. In particular, the service sectors that received the highest labor inflows were "Wholesale, Retail, Hotels, Restaurants" and "Business Services".

Fact 6: The proportion of high-skilled workers increased overall, and most significantly in the Business Services and MCEE sectors.

We now examine how the sectoral patterns in both trade and labor markets mattered for skill acquisitions of workers. As indicated in Table 5, the average years of schooling of workers were the highest in the MCEE, Electricity, Gas & Water (EGW), and Business Services sectors, while they were the lowest in the primary sector.[3] Except for the EGW sector, these sectors were also those with the largest labor inflows. This suggests that the expanding sectors were also the most skill intensive.

Figure 5 shows the evolution of the annual share of low-skilled (with $\leqslant$ junior-high school education), middle-skilled (with senior-high or vocational school education), and high-skilled workers (with college education) in each sector. Overall, the shares of high-, middle-, and low-skilled workers in the population changed from 17.4%, 30.3%, and 52.3% in 1995 to 34.7%, 34.5%, and 30.8% in 2007, respectively.[4] That is, the proportion of high-skilled workers increased substantially while that of low-skilled decreased. It is evident that the proportion of high-skilled workers increased the most in the MCEE, EGW, and Business Services sectors, which suggests increasing demand for high-skilled workers in the expanding sectors.

[3]The EGW sector in Taiwan is mainly state-owned, and one needs to pass certain entrance exams in order to enter this sector. This may help explain the high average years of schooling of workers in this sector.

[4]The total population is measured as the sum of employed, unemployed, and not-in-labor-force, as elaborated in Appendix A.1.

Fact 7: The capital stock grew disproportionately in the MCEE and key service sectors.

Table 6 presents Taiwan's capital stock allocation across sectors for two snapshot years 1996 and 2006, when the data are available. Overall, the economy-wide capital stock grew by 67% during the period. The MCEE sector stood out as the sector whose capital stock grew the most (by 240%), followed by sectors in Transport/Storage Services and Business Services. In contrast, the primary and labor-intensive manufacturing/services sectors experienced either negative or slower capital accumulation.

In sum, we have documented seven key stylized facts on tariffs, trade patterns, labor markets, and capital dynamics in Taiwan during the period 1995–2007. Taken together, these stylized facts reflect the rapid dynamic responses of Taiwan to its accession to the WTO and the China shocks (in both senses of China's increased openness and productivity growth). In particular, the role of skill upgrading mattered significantly in the transformation of Taiwan's trade structure — the shrinking/expanding sectors that were less/more skill-intensive in nature exerted push/pull force that motivated skill acquisition on the supply side. We now generalize the dynamic general-equilibrium framework of CDP to allow for skill transitions (in addition to sector transitions) in workers' choices, capital dynamics, and skill-capital complementarity in production. This will allow us to evaluate the quantitative impact of Taiwan's WTO accession on its local labor markets, and the importance of the China shocks, skill-upgrade and capital accumulation mechanisms in explaining its dynamic adjustments.

3 Model

We extend the dynamic hat algebra framework of Caliendo, Dvorkin and Parro (2019) to allow for: sector-skill transition, endogenous capital accumulation, and skill-capital complementarity in production.

The world consists of N economies, and $J+1$ sectors, with workers of S different skill levels and capital owners. We denote the economies by $n, o \in \{1, 2, \ldots, N\}$ and sectors by $j, k \in \{0, 1, 2, \ldots, J\}$, where $j = 0$ corresponds to non-employment (jobless). The worker skill level is indexed by $s, i \in \{1, 2, 3\}$, with 1/2/3 representing low-/middle-/high-skill level, respectively.

3.1 Workers: Consumption

Each employed worker inelastically supplies one unit of labor, and earns a competitive market wage w_t^{njs} in period t. An njs worker consumes local final goods from all sectors with a Cobb-Douglas aggregator:

$$C_t^{njs} = \prod_{k=1}^{J} \left(c_t^{njs,k}\right)^{\alpha^{nk}},$$

where $\sum_{k=1}^{J} \alpha^{nk} = 1$, with a corresponding price index denoted by $P_t^n = \prod_{k=1}^{J} \left(\frac{P_t^{nk}}{\alpha^{nk}}\right)^{\alpha^{nk}}$, where P_t^{nk} is the price index of goods of sector k in economy n to be derived below. Jobless workers (of any skill level) perform home production, and consume

$$C_t^{n0s} = b^n > 0, \quad \forall s.$$

Utility per period is determined by the final goods consumed, defined as: $U\left(C_t^{njs}\right) \equiv \ln C_t^{njs}$.

3.2 Workers: Sector-Skill Choice

In each period, workers choose endogenously the sector of employment and whether or not to upgrade their skills. Given that skill transition is unidirectional, we introduce mortality and new birth to replenish the pool of low-skilled workers. In particular, let L_0^{njs} denote the initial mass of labor with sector-skill combination js in economy n, which adds up to the total population $L^n = \sum_{j=0}^{J} \sum_{s=1}^{3} L_0^{njs}$. In each period, a fraction of the workers die, with a survival rate given by δ, while new agents are born into the home production sector ($j = 0$) with low-skill level ($s = 0$). We assume that the death rate equals the birth rate so that the total population size is constant over time.

In each period t, an agent of sector-skill combination js in economy n chooses a sector-skill combination for the coming period (ki) in a forward-looking manner. Agents observe all economic conditions and the realizations of their own idiosyncratic preference shocks ϵ_t^{ki} (with respect to each ki combination) before making decisions. We denote the cost of transition from sector-skill combination js to ki by $\rho^{njs,nki} \geq 0$. A choice of $i > s$ indicates skill-upgrading by the agent. To capture the *irreversibility* of education, we assume that $\rho = \infty$ for $i < s$, so in practice skill downgrading is not observed. The above setup implies that the lifetime utility v_t^{njs} of an agent is given by the following Bellman equation:

$$v_t^{njs} = \ln C_t^{njs} + \max_{\{k,i\}_{k=0,i=1}^{J,3}} \left\{\beta\delta V_{t+1}^{nki} - \rho^{njs,nki} + \nu\epsilon_t^{ki}\right\}, \tag{1}$$

where β is the discount rate; V_{t+1}^{nki} denotes the expected lifetime utility of an agent with sector-skill combination ki at period $t+1$, with the expectation taken over future realizations of the idiosyncratic shocks; and the parameter ν scales the variance of the idiosyncratic shocks. The idiosyncratic shocks ϵ_t^{ki} are assumed to be *i.i.d.* over time, and drawn from a Type-I extreme value distribution: $F(\epsilon) = e^{-e^{(-\epsilon-\gamma)}}$, with γ representing the Euler constant. Note that the extra discount factor δ on future utilities is introduced by the possibility of death, in addition to the time discount factor β. We assume that wages are the only source of income for workers; it follows that consumption is given by: $C_t^{njs} = \frac{w_t^{njs}}{P_t^n} \equiv \omega_t^{njs}$ for $j \neq 0$, and $C_t^{n0s} = b^n$.

3.3 Workers: Labor Market Transition Probabilities

Given the distribution of ϵ_t^{ki}, it follows that the lifetime expected utility V_t^{njs} is:

$$V_t^{njs} = \ln C_t^{njs} + \nu \ln \sum_{\text{K}=0}^{J} \sum_{\text{I}\geq s}^{3} e^{\frac{\beta\delta V_{t+1}^{n\text{KI}} - \rho^{njs,n\text{KI}}}{\nu}}, \tag{2}$$

and the probability $\mu_t^{njs,nki}$ of transition from sector-skill js to cell ki is:

$$\mu_t^{njs,nki} = \frac{e^{\frac{\beta\delta V_{t+1}^{nki} - \rho^{njs,nki}}{\nu}}}{\sum_{\text{K}=0}^{J} \sum_{\text{I}\geq s}^{3} e^{\frac{\beta\delta V_{t+1}^{n\text{KI}} - \rho^{njs,n\text{KI}}}{\nu}}}. \tag{3}$$

The laws of motion for the labor pool in each sector-skill combination are thus:

$$L_{t+1}^{njs} = \delta \sum_{k=0}^{J} \sum_{i\leq s}^{3} \mu_t^{nki,njs} L_t^{nki}, \; js \neq 01, \tag{4}$$

$$L_{t+1}^{n01} = \delta \sum_{k=0}^{J} \mu_t^{nk1,n01} L_t^{nk1} + (1-\delta) L^n, \tag{5}$$

where the population size L^n remains constant by assumption (that the death rate equals the birth rate); and $(1-\delta) L^n$ represents the new additions to the population that start with non-employment and low skill.

3.4 Capital Owners

Capital stocks are used locally and owned by a unit mass of local rentiers. Let K_t^n denote the capital stock of economy n at period t, and r_t^n the corresponding rental rate that clears the market such that:

$$K_t^n = \sum_{j=1}^{J} K_t^{nj}, \tag{6}$$

where K_t^{nj} is the demand for capital by sector j in economy n at period t. The rental income can be used for consumption or invested to expand the capital stock. Formally, the capital owner's optimization problem is given by:

$$\max_{\left\{C_t^{nK}, K_{t+1}^n\right\}} \sum_{t=0}^{\infty} \beta^t \ln C_t^{nK}$$
$$s.t.\ P_t^n \left[C_t^{nK} + K_{t+1}^n - \left(1-\delta^K\right) K_t^n\right] = r_t^n K_t^n,$$

where C_t^{nK} denotes the final goods consumed by the capital owner, and δ^K the capital depreciation rate. Note that the same Cobb-Douglas composite product as consumed by workers is used for consumption or investment by capital owners.

Following similar derivations as in Kleinman, Liu and Redding (2023), we can solve for the optimal consumption choice of the capital owner and the implied capital dynamics as:

$$C_t^{nK} = (1-\beta)\left[\varphi_t^n + \left(1-\delta^K\right)\right] K_t^n, \tag{7}$$
$$K_{t+1}^n = \beta\left[\varphi_t^n + \left(1-\delta^K\right)\right] K_t^n, \tag{8}$$

where $\varphi_t^n \equiv r_t^n / P_t^n$ denotes the real rental rate. The capital owner's lifetime utility V_t^{nK} satisfies the following condition:

$$V_t^{nK} = \sum_{s=t}^{\infty} \beta^{s-t} \ln C_s^{nK} \equiv \ln C_t^{nK} + \beta V_{t+1}^{nK}. \tag{9}$$

3.5 Production and Trade

Our setup for production and trade generalizes the setups of Eaton and Kortum (2002) and Caliendo and Parro (2015) by differentiating skills as different inputs, and incorporating capital and skill-capital complementarity.

The production technology is characterized by a Cobb-Douglas production function in value-added and intermediate inputs, and a two-tier CES value-added function (which exhibits complementarity between capital and high-skilled labor in the inner tier and substitutability between low-skilled, middle-skilled, and capital-enhanced high-skilled labor inputs in the outer tier). Specifically, in each economy-sector nj, a unit continuum of intermediate goods varieties is produced by perfectly competitive firms with heterogeneous productivity levels z^{nj}. Firms in sector j of economy n combine capital K_t^{nj}, labor of three skill types l_t^{njs}, and intermediate inputs $M_t^{nj,nk}$ in a nested Cobb-Douglas-CES manner to produce an output quantity of:

$$q_t^{nj} \quad = \quad z^{nj} \left(A_t^{nj} \widetilde{l}_t^{nj} \right)^{\gamma^{nj}} \prod_{k=1}^{J} \left(M_t^{nj,nk} \right)^{\gamma^{nj,nk}},$$

where

$$\widetilde{l}_t^{nj} \quad \equiv \quad \left[\left(\zeta^{nj1}\right)^{\frac{1}{\xi^{nj}}} \left(l_t^{nj1}\right)^{\frac{\xi^{nj}-1}{\xi^{nj}}} + \left(\zeta^{nj2}\right)^{\frac{1}{\xi^{nj}}} \left(l_t^{nj2}\right)^{\frac{\xi^{nj}-1}{\xi^{nj}}} + \left(\zeta^{njh}\right)^{\frac{1}{\xi^{nj}}} \left(h_t^{nj}\right)^{\frac{\xi^{nj}-1}{\xi^{nj}}} \right]^{\frac{\xi^{nj}}{\xi^{nj}-1}},$$

$$h_t^{nj} \quad = \quad \left[\left(\zeta^{nj3}\right)^{\frac{1}{\xi^{njh}}} \left(l_t^{nj3}\right)^{\frac{\xi^{njh}-1}{\xi^{njh}}} + \left(\zeta^{njK}\right)^{\frac{1}{\xi^{njh}}} \left(K_t^{nj}\right)^{\frac{\xi^{njh}-1}{\xi^{njh}}} \right]^{\frac{\xi^{njh}}{\xi^{njh}-1}}.$$

In the production function above, $M_t^{nj,nk}$ is the intermediate input demanded by a firm in sector j from sector k within economy n; A_t^{nj} is the time-varying economy-sector specific productivity level; γ^{nj} is the share of value-added, such that $\gamma^{nj} = 1 - \sum_k \gamma^{nj,nk}$; ξ^{njh} corresponds to the elasticity of substitution between high-skilled labor l_t^{nj3} and capital K_t^{nj}; and ξ^{nj} corresponds to the elasticity of substitution between low-skilled l_t^{nj1}, middle-skilled l_t^{nj2}, and capital-enhanced high-skilled h_t^{nj} labor inputs. The parameters $\{\zeta^{njs}\}_{s=1,2,3,h,K}$ denote the weights of the corresponding factors in the CES value-added function. The vector $z^j = \left(z^{1j}, ..., z^{Nj}\right)$ represents the productivity draws of the N economies in sector j for a variety. Assume that the productivity vector z^j follows a joint Fréchet distribution, with:

$$\phi^j \left(z^j\right) \quad = \quad e^{-\sum_{o=1}^{N} \left(z^{oj}\right)^{-\theta^j}},$$

which implies that the economy-sector-specific cumulative density function of firm-level productivity draws is given by $\phi^{nj}\left(z^{nj}\right) = e^{-\left(z^{nj}\right)^{-\theta^j}}$.

It follows that the unit price of an input bundle is given by:

$$x_t^{nj} = B^{nj} \left(\chi_t^{nj}\right)^{\gamma^{nj}} \prod_{k=1}^{J} \left(P_t^{nk}\right)^{\gamma^{nj,nk}}, \tag{10}$$

where

$$\chi_t^{nj} \quad = \quad \left[\zeta^{nj1} \left(w_t^{nj1}\right)^{1-\xi^{nj}} + \zeta^{nj2} \left(w_t^{nj2}\right)^{1-\xi^{nj}} + \zeta^{njh} \left(\chi_t^{njh}\right)^{1-\xi^{nj}} \right]^{\frac{1}{1-\xi^{nj}}}; \tag{11}$$

$$\chi_t^{njh} = \left[\zeta^{nj3}\left(w_t^{nj3}\right)^{1-\xi^{njh}} + \zeta^{njK}\left(r_t^n\right)^{1-\xi^{njh}}\right]^{\frac{1}{1-\xi^{njh}}}; \tag{12}$$

B^{nj} is a constant; w_t^{njs} is the wage rate of skill-type s in economy-sector nj; χ_t^{nj} and χ_t^{njh} denote the unit cost of the value-added bundle $\widetilde{l}_t^{nj}$ and the capital-enhanced high-skilled bundle h_t^{nj}, respectively; and P_t^{nk} is the same price index of sector k in economy n as for consumption (to be derived below).

Exporting intermediate goods of sector j from economy o to n incurs iceberg trade cost ($d_t^{nj,oj}$) as well as ad valorem tariffs ($\tau_t^{nj,oj}$) imposed by economy n, such that: $\kappa_t^{nj,oj} \equiv d_t^{nj,oj}\left(1+\tau_t^{nj,oj}\right) \geq 1$. Competitive markets imply that the price of a variety of goods in economy-sector nj is given by:

$$p_t^{nj}\left(z^j\right) = \min_o \left\{\frac{\kappa_t^{nj,oj} x_t^{oj}}{z^{oj}\left(A_t^{oj}\right)^{\gamma^{oj}}}\right\}.$$

Intermediate goods demanded by economy n in sector j from all sources, $\widetilde{q}_t^{nj}$, are aggregated into a local sectoral good in a CES manner, denoted by:

$$Q_t^{nj} = \left[\int \left(\widetilde{q}_t^{nj}\left(z^j\right)\right)^{1-\frac{1}{\eta^{nj}}} d\phi^j\left(z^j\right)\right]^{\frac{\eta^{nj}}{\eta^{nj}-1}},$$

where η^{nj} denotes economy n's elasticity of substitution across varieties of sector j. The local final goods of sector j are then used either for consumption by local workers ($c_t^{nks,j}$), for consumption or investment by local capital owners, or used as intermediate inputs by domestic firms from all sectors ($M_t^{nk,nj}$).

The sectoral price index is equal to:

$$P_t^{nj} = \left[\sum_o \left(\kappa_t^{nj,oj} x_t^{oj}\right)^{-\theta^j}\left(A_t^{oj}\right)^{\gamma^{oj}\theta^j}\right]^{-\frac{1}{\theta^j}} \left(\Gamma^{nj}\left(\frac{1-\eta^{nj}+\theta^j}{\theta^j}\right)\right)^{\frac{1}{1-\eta^j}}, \tag{13}$$

and the share of intermediate varieties in sector j that economy n imports from economy o is:

$$\pi_t^{nj,oj} = \frac{\left(\kappa_t^{nj,oj} x_t^{oj}\right)^{-\theta^j}\left(A_t^{oj}\right)^{\gamma^{oj}\theta^j}}{\sum_{\mathrm{o}} \left(\kappa_t^{nj,\mathrm{o}j} x_t^{\mathrm{o}j}\right)^{-\theta^j}\left(A_t^{\mathrm{o}j}\right)^{\gamma^{\mathrm{o}j}\theta^j}}. \tag{14}$$

3.6 Market Clearing

Let X_t^{nj} denote economy n's total expenditure on sector-j goods. The goods market-clearing condition requires that:

$$
\begin{aligned}
X_t^{nj} \; &= \; \sum_{k=1}^{J} \gamma^{nk,nj} \sum_{\text{o}=1}^{N} \frac{\pi_t^{\text{o}k,nk} X_t^{\text{o}k}}{1+\tau_t^{\text{o}k,nk}} \\
&\quad + \alpha^{nj} \left(\sum_{k=1}^{J} \sum_{s=1}^{3} w_t^{nks} L_t^{nks} + r_t^n K_t^n + \sum_{k=1}^{J} \sum_{\text{o}=1}^{N} \tau_t^{nk,\text{o}k} \frac{\pi_t^{nk,\text{o}k} X_t^{nk}}{1+\tau_t^{nk,\text{o}k}} + D_t^n \right),
\end{aligned} \tag{15}
$$

where the first term on the right-hand side corresponds to local firms' expenditures on sector-j goods as intermediate inputs (the summation term right after $\gamma^{nk,nj}$ is each sector-k's total production cost); and the second big term reflects the final demand for sector-j goods by workers (given their wage income), rentiers (given their rental income), and the government (given the tariff revenues), with an extra term D_t^n reflecting the economy's trade deficit. We assume that the trade deficit of country n in year t is a constant share ι_t^n of the global gross output:

$$
D_t^n \equiv \iota_t^n \sum_{k=1}^{J} \sum_{\text{o}=1}^{N} X_t^{\text{o}k},
$$

such that $\sum_n \iota_t^n = 0$ and $\sum_n D_t^n = 0$. See, for example, Caliendo and Parro (2015) for similar approaches. We calibrate ι_t^n to its data equivalent: $D_t^n / \sum_{k=1}^{J} \sum_{\text{o}=1}^{N} X_t^{\text{o}k}$. For years beyond the data period, we use ι_T^n from the final data year T when simulating the baseline and counterfactual economies.

Perfect competition and the production function together imply that the market-clearing conditions for labor and capital markets are respectively:

$$
w_t^{njs} L_t^{njs} \; = \; \gamma_t^{L,njs} \sum_{\text{o}=1}^{N} \frac{\pi_t^{\text{o}j,nj} X_t^{\text{o}j}}{1+\tau_t^{\text{o}j,nj}}, \quad \forall s \tag{16}
$$

$$
r_t^n K_t^{nj} \; = \; \gamma_t^{K,nj} \sum_{\text{o}=1}^{N} \frac{\pi_t^{\text{o}j,nj} X_t^{\text{o}j}}{1+\tau_t^{\text{o}j,nj}}, \tag{17}
$$

where $\left\{\gamma_t^{L,njs}\right\}_{s=1}^{3}$ and $\gamma_t^{K,nj}$ are the cost shares of the respective input factors defined by:

$$
\gamma_t^{L,nj1} \; \equiv \; \zeta^{nj1} \left(\frac{w_t^{nj1}}{\chi_t^{nj}} \right)^{1-\xi^{nj}} \gamma^{nj}, \tag{18}
$$

$$\gamma_t^{L,nj2} \equiv \zeta^{nj2}\left(\frac{w_t^{nj2}}{\chi_t^{nj}}\right)^{1-\xi^{nj}} \gamma^{nj}, \tag{19}$$

$$\gamma_t^{L,nj3} \equiv \zeta^{njh}\left(\frac{\chi_t^{njh}}{\chi_t^{nj}}\right)^{1-\xi^{nj}} \zeta^{nj3}\left(\frac{w_t^{nj3}}{\chi_t^{njh}}\right)^{1-\xi^{njh}} \gamma^{nj}, \tag{20}$$

$$\gamma_t^{K,nj} \equiv \zeta^{njh}\left(\frac{\chi_t^{njh}}{\chi_t^{nj}}\right)^{1-\xi^{nj}} \zeta^{njK}\left(\frac{r_t^{n}}{\chi_t^{njh}}\right)^{1-\xi^{njh}} \gamma^{nj}. \tag{21}$$

It can be readily checked that $\gamma^{nj} = \sum_{s=1}^{3} \gamma_t^{L,njs} + \gamma_t^{K,nj}$.

3.7 Equilibrium

We now characterize the dynamic equilibrium of the economy. Let $\Theta_t \equiv (A_t, d_t, \tau_t)$ denote the set of time-varying fundamentals. This includes the economy-sector productivities $A_t = \left\{A_t^{nj}\right\}$, the iceberg trade costs $d_t = \left\{d_t^{nj,oj}\right\}$, and the tariff wedges $\tau_t = \left\{\tau_t^{nj,oj}\right\}$. Let $\overline{\Theta} \equiv (\rho, b, \zeta)$ collect the set of constant fundamentals, which include the labor transition costs $\rho = \left\{\rho^{njs,nki}\right\}$, home production $b = \{b^n\}$, and the CES value-added function shift parameters $\zeta = \{\zeta^{njs}\}_{s=1,2,3,h,K}$. The other parameters of the model include the elasticity of substitution between high-skilled labor and capital (ξ^{njh}), and that between low-skilled, middle-skilled, and capital-enhanced high-skilled labor inputs (ξ^{nj}); the value-added shares (γ^{nj}); the input-output coefficients ($\gamma^{nj,nk}$); the deficit shares (ι_t^n); the final demand expenditure shares (α^{nj}); the discount factor (β); the survival rate (δ); the capital depreciation rate (δ^K); the trade elasticity (θ^j); and the scaling factor for the variance of the idiosyncratic shocks (ν).

As in CDP, we solve the dynamic equilibrium in two loops: first in terms of temporary equilibrium (for each period) and then in terms of sequential equilibrium (across periods). In each period, given $\left(L_t, K_t, \Theta_t, \overline{\Theta}\right)$, a temporary equilibrium is a vector of factor prices $w\left(L_t, K_t, \Theta_t, \overline{\Theta}\right)$ and $r\left(L_t, K_t, \Theta_t, \overline{\Theta}\right)$ that satisfy the equilibrium conditions (6) and (10)–(17). Given $\left(L_0, K_0, \{\Theta_t\}_{t=0}^{\infty}, \overline{\Theta}\right)$, a sequential equilibrium is a sequence of $\left\{L_t, \mu_t, V_t, K_t, w\left(L_t, K_t, \Theta_t, \overline{\Theta}\right), r\left(L_t, K_t, \Theta_t, \overline{\Theta}\right)\right\}_{t=0}^{\infty}$ that solves the equilibrium conditions (2)–(5) and (8), and the temporary equilibrium at each t, where $\mu_t = \left\{\mu_t^{njs,nki}\right\}$ and $V_t = \left\{V_t^{njs}\right\}$.

3.8 Dynamic Hat Algebra

We now characterize the equilibrium in terms of *time differences*. This greatly reduces the set of parameters required to implement the analysis. In fact, the equilibrium in time differences can be solved without information on the level of the fundamentals $\{\Theta_t\}_{t=1}^{\infty}$ or $\overline{\Theta}$, as elaborated in CDP. Given the baseline economy's equilibrium path over time, we can then conduct counterfactual analysis and study how allocations change across space, sector, skill and time, relative to the baseline economy, given a new sequence of fundamentals $\{\Theta'_t\}_{t=1}^{\infty}$.

Let $\dot{y}_{t+1} \equiv y_{t+1}/y_t$ represent the change of y over time and $\widehat{y}_{t+1} \equiv \dot{y}'_{t+1}/\dot{y}_{t+1}$ the relative change between the counterfactual equilibrium path $\dot{y}'_{t+1} \equiv y'_{t+1}/y'_t$ and the baseline equilibrium path $\dot{y}_{t+1} \equiv y_{t+1}/y_t$. The following propositions summarize the equilibrium conditions. The derivations of all the propositions are provided in Online Appendix A.

Proposition 1. *Given the allocation of the temporary equilibrium at t,* $\left\{L_t, K_t, \pi_t, X_t, \gamma_t^L, \gamma_t^K\right\}$, *consider a given change in terms of* $\dot{L}_{t+1}$, $\dot{K}_{t+1}$ *and* $\dot{\Theta}_{t+1}$. *The temporary equilibrium at time* $t+1$ *solves the following equations, and requires no information on the level of fundamentals at* t*:*

$$\dot{x}_{t+1}^{nj} = \left[\dot{\chi}_{t+1}^{nj}\left(\dot{w}_{t+1}^{nj1}, \dot{w}_{t+1}^{nj2}, \dot{w}_{t+1}^{nj3}, \dot{r}_{t+1}^{n}\right)\right]^{\gamma^{nj}} \prod_{k=1}^{J}\left(\dot{P}_{t+1}^{nk}\right)^{\gamma^{nj,nk}} \tag{22}$$

$$\dot{P}_{t+1}^{nj} = \left[\sum_{o} \pi_t^{nj,oj}\left(\dot{\kappa}_{t+1}^{nj,oj}\,\dot{x}_{t+1}^{oj}\right)^{-\theta^j}\left(\dot{A}_{t+1}^{oj}\right)^{\gamma^{oj}\theta^j}\right]^{-\frac{1}{\theta^j}} \tag{23}$$

$$\pi_{t+1}^{nj,oj} = \pi_t^{nj,oj}\left(\frac{\dot{\kappa}_{t+1}^{nj,oj}\,\dot{x}_{t+1}^{oj}}{\dot{P}_{t+1}^{nj}}\right)^{-\theta^j}\left(\dot{A}_{t+1}^{oj}\right)^{\gamma^{oj}\theta^j} \tag{24}$$

$$\begin{aligned} X_{t+1}^{nj} = {} & \sum_{k=1}^{J}\gamma^{nk,nj}\sum_{\mathrm{o}=1}^{N}\frac{\pi_{t+1}^{\mathrm{o}k,nk}X_{t+1}^{\mathrm{o}k}}{1+\tau_{t+1}^{\mathrm{o}k,nk}} \\ & +\alpha^{nj}\left(\sum_{k=1}^{J}\sum_{s=1}^{3}\dot{w}_{t+1}^{nks}\dot{L}_{t+1}^{nks}\,w_t^{nks}L_t^{nks}+\dot{r}_{t+1}^{n}\dot{K}_{t+1}^{n}r_t^nK_t^n\right) \\ & +\alpha^{nj}\left(\sum_{k=1}^{J}\sum_{\mathrm{o}=1}^{N}\tau_{t+1}^{nk,\mathrm{o}k}\frac{\pi_{t+1}^{nk,\mathrm{o}k}X_{t+1}^{nk}}{1+\tau_{t+1}^{nk,\mathrm{o}k}}+\iota_t^n\sum_{k=1}^{J}\sum_{\mathrm{o}=1}^{N}X_{t+1}^{\mathrm{o}k}\right) \end{aligned} \tag{25}$$

$$\dot{w}_{t+1}^{njs}\dot{L}_{t+1}^{njs}\,w_t^{njs}L_t^{njs} = \gamma_{t+1}^{L,njs}\sum_{\mathrm{o}=1}^{N}\frac{\pi_{t+1}^{\mathrm{o}j,nj}X_{t+1}^{\mathrm{o}j}}{1+\tau_{t+1}^{\mathrm{o}j,nj}}, \qquad s\in\{1,2,3\} \tag{26}$$

$$\dot{r}_{t+1}^{n}\dot{K}_{t+1}^{n}r_t^nK_t^n = \sum_{j=1}^{J}\gamma_{t+1}^{K,nj}\sum_{\mathrm{o}=1}^{N}\frac{\pi_{t+1}^{\mathrm{o}j,nj}X_{t+1}^{\mathrm{o}j}}{1+\tau_{t+1}^{\mathrm{o}j,nj}} \tag{27}$$

$$\dot{P}_{t+1}^{n} = \prod_{j=1}^{J}\left(\dot{P}_{t+1}^{nj}\right)^{\alpha^{nj}} \tag{28}$$

where

$$\begin{aligned}
\left(\dot{\chi}_{t+1}^{njh}\right)^{1-\xi^{njh}} &= \frac{\gamma_t^{L,nj3}}{\gamma_t^{L,njh}}\left(\dot{w}_{t+1}^{nj3}\right)^{1-\xi^{njh}} + \frac{\gamma_t^{K,nj}}{\gamma_t^{L,njh}}\left(\dot{r}_{t+1}^{n}\right)^{1-\xi^{njh}} \\
\left(\dot{\chi}_{t+1}^{nj}\right)^{1-\xi^{nj}} &= \frac{\gamma_t^{L,nj1}}{\gamma^{nj}}\left(\dot{w}_{t+1}^{nj1}\right)^{1-\xi^{nj}} + \frac{\gamma_t^{L,nj2}}{\gamma^{nj}}\left(\dot{w}_{t+1}^{nj2}\right)^{1-\xi^{nj}} + \frac{\gamma_t^{L,njh}}{\gamma^{nj}}\left(\dot{\chi}_{t+1}^{njh}\right)^{1-\xi^{nj}} \\
\gamma_t^{L,njh} &\equiv \gamma_t^{L,nj3} + \gamma_t^{K,nj}
\end{aligned}$$

and the change in the cost shares of labor and capital inputs are given by: $\dot{\gamma}_{t+1}^{L,nj1} = \left(\dot{w}_{t+1}^{nj1}/\dot{\chi}_{t+1}^{nj}\right)^{1-\xi^{nj}}$, $\dot{\gamma}_{t+1}^{L,nj2} = \left(\dot{w}_{t+1}^{nj2}/\dot{\chi}_{t+1}^{nj}\right)^{1-\xi^{nj}}$, $\dot{\gamma}_{t+1}^{L,njh} = \left(\dot{\chi}_{t+1}^{njh}/\dot{\chi}_{t+1}^{nj}\right)^{1-\xi^{nj}}$, $\dot{\gamma}_{t+1}^{L,nj3} = \dot{\gamma}_{t+1}^{L,njh}\left(\dot{w}_{t+1}^{nj3}/\dot{\chi}_{t+1}^{njh}\right)^{1-\xi^{njh}}$, $\dot{\gamma}_{t+1}^{K,nj} = \dot{\gamma}_{t+1}^{L,njh}\left(\dot{r}_{t+1}^{n}/\dot{\chi}_{t+1}^{njh}\right)^{1-\xi^{njh}}$.

Proposition 1 implies that given $\left\{L_t^{njs}, K_t^n, \pi_t^{nj,oj}, X_t^{nj}, \left\{\gamma_t^{L,njs}\right\}_{s=1}^{3}, \gamma_t^{K,nj}, \dot{L}_{t+1}^{njs}, \dot{K}_{t+1}^{n}, \dot{\Theta}_{t+1}\right\}$ for all $\{n, j, s\}$, one can solve for the change in the allocation of the temporary equilibrium between t and $t+1$, and in the real factor prices based on $\left\{\dot{w}_{t+1}^{njs}, \dot{r}_{t+1}^{n}, \dot{P}_{t+1}^{nj}\right\}$. The next step then characterizes the changes $\dot{L}_{t+1}^{njs}$ and $\dot{K}_{t+1}^{n}$ that are consistent with the sequential equilibrium in time differences.

Proposition 2. *Define* $u_t^{njs} \equiv e^{V_t^{njs}}$ *and* $u_t^{nK} \equiv e^{V_t^{nK}}$. *Conditional on an initial allocation of the economy* $(L_0, K_0, \pi_0, X_0, \varphi_0, \mu_{-1})$, *given an anticipated convergent sequence of changes in fundamentals* $\left\{\dot{\Theta}_t\right\}_{t=1}^{\infty}$, *the solution to the sequential equilibrium in time differences satisfies the following equations and requires no information on the level of fundamentals* $\left(\{\Theta_t\}_{t=0}^{\infty}, \overline{\Theta}\right)$*:*

$$\mu_{t+1}^{njs,nki} = \frac{\mu_t^{njs,nki}\left(\dot{u}_{t+2}^{nki}\right)^{\frac{\beta\delta}{\nu}}}{\sum_{\mathrm{K}=0}^{J}\sum_{\mathrm{I}\geq s}^{3}\mu_t^{njs,n\mathrm{KI}}\left(\dot{u}_{t+2}^{n\mathrm{KI}}\right)^{\frac{\beta\delta}{\nu}}} \tag{29}$$

$$\dot{u}_{t+1}^{njs} = \dot{\omega}_{t+1}^{njs}\left[\sum_{\mathrm{K}=0}^{J}\sum_{\mathrm{I}\geq s}^{3}\mu_t^{njs,n\mathrm{KI}}\left(\dot{u}_{t+2}^{n\mathrm{KI}}\right)^{\frac{\beta\delta}{\nu}}\right]^{\nu} \tag{30}$$

$$\dot{u}_{t+1}^{nK} = \dot{K}_{t+2}^{n}\left(\dot{u}_{t+2}^{nK}\right)^{\beta} \tag{31}$$

$$L_{t+1}^{njs} = \delta\sum_{k=0}^{J}\sum_{i\leq s}^{3}\mu_t^{nki,njs}L_t^{nki}, \;\; js \neq 01 \tag{32}$$

$$L_{t+1}^{n01} = \delta\sum_{k=0}^{J}\mu_t^{nk1,n01}L_t^{nk1} + (1-\delta)\,L^n \tag{33}$$

$$K_{t+1}^{n} = \beta\left[\varphi_t^n + \left(1-\delta^K\right)\right]K_t^n \tag{34}$$

where $\left\{\dot{\omega}_t^{njs}\right\}$ *and* $\varphi_t^n \equiv r_t^n/P_t^n = \left(\dot{r}_t^n/\dot{P}_t^n\right)\varphi_{t-1}^n$ *are implied by the solutions to the temporary* *equilibrium given* $\left\{\dot{L}_t, \dot{K}_t, \dot{\Theta}_t\right\}$ *characterized in Proposition 1.*

In sum, with Propositions 1 and 2 combined, one can solve the baseline economy in time differences, for a given sequence of changes in fundamentals, using data on initial labor allocation L_0, capital stock K_0, real interest rate φ_0, cost shares of labor inputs γ_0^L and capital inputs γ_0^K, trade share π_0, aggregate expenditure X_0, and transition matrix μ_{-1}.

Proposition 3. *Consider a counterfactual convergent sequence of changes in fundamentals relative to the baseline change* $\left\{\widehat{\Theta}_t\right\}_{t=1}^{\infty}$. *Given the allocation under the baseline fundamentals* $\left\{L_t, K_t, \pi_t, X_t, \mu_{t-1}, \gamma_t^L, \gamma_t^K\right\}_{t=0}^{\infty}$, *the counterfactual sequential allocation* $\left\{L_t', K_t', \pi_t', X_t', \mu_{t-1}', \gamma_t'^L, \gamma_t'^K\right\}_{t=0}^{\infty}$ *satisfies the following equations and does not require information on the baseline fundamentals* $(\{\Theta_t\}_{t=0}^{\infty}, \overline{\Theta})$*:*

$$\mu_{t+1}'^{njs,nki} = \frac{\mu_t'^{njs,nki}\dot{\mu}_{t+1}^{njs,nki}\left(\widehat{u}_{t+2}^{nki}\right)^{\frac{\beta\delta}{\nu}}}{\sum_{\mathrm{K}=0}^{J}\sum_{\mathrm{I}\geq s}^{3}\mu_t'^{njs,n\mathrm{KI}}\dot{\mu}_{t+1}^{njs,n\mathrm{KI}}\left(\widehat{u}_{t+2}^{n\mathrm{KI}}\right)^{\frac{\beta\delta}{\nu}}} \tag{35}$$

$$\widehat{u}_{t+1}^{njs} = \widehat{\omega}_{t+1}^{njs}\left[\sum_{\mathrm{K}=0}^{J}\sum_{\mathrm{I}\geq s}^{3}\mu_t'^{njs,n\mathrm{KI}}\dot{\mu}_{t+1}^{njs,n\mathrm{KI}}\left(\widehat{u}_{t+2}^{n\mathrm{KI}}\right)^{\frac{\beta\delta}{\nu}}\right]^{\nu} \tag{36}$$

$$\widehat{u}_{t+1}^{nK} = \widehat{K}_{t+2}^{n}\left(\widehat{u}_{t+2}^{nK}\right)^{\beta} \tag{37}$$

$$L_{t+1}'^{njs} = \delta\sum_{k=0}^{J}\sum_{i\leq s}^{3}\mu_t'^{nki,njs}L_t'^{nki}, \;\; js \neq 01 \tag{38}$$

$$L_{t+1}'^{n01} = \delta\sum_{k=0}^{J}\mu_t'^{nk1,n01}L_t'^{nk1} + (1-\delta)\,L^n \tag{39}$$

$$K_{t+1}'^{n} = \beta\left[\varphi_t'^{n} + \left(1-\delta^K\right)\right]K_t'^{n}, \tag{40}$$

where $\widehat{\omega}_{t+1}^{njs}$ *and* $\varphi_t'^{n} \equiv r_t'^{n}/P_t'^{n}$ *are implied by the solutions to the temporary equilibrium given* $\left(\widehat{L}_{t+1}, \widehat{K}_t, \widehat{\Theta}_{t+1}\right)$ *at each t:*

$$\widehat{x}_{t+1}^{nj} = \left(\widehat{\chi}_{t+1}^{nj}\right)^{\gamma^{nj}}\prod_{k=1}^{J}\left(\widehat{P}_{t+1}^{nk}\right)^{\gamma^{nj,nk}} \tag{41}$$

$$\widehat{P}_{t+1}^{nj} = \left[\sum_{o}\pi_t'^{nj,oj}\dot{\pi}_{t+1}^{nj,oj}\left(\widehat{\kappa}_{t+1}^{nj,oj}\widehat{x}_{t+1}^{oj}\right)^{-\theta^j}\left(\widehat{A}_{t+1}^{oj}\right)^{\gamma^{oj}\theta^j}\right]^{-\frac{1}{\theta^j}} \tag{42}$$

$$\pi_{t+1}'^{nj,oj} = \pi_t'^{nj,oj}\dot{\pi}_{t+1}^{nj,oj}\left(\frac{\widehat{\kappa}_{t+1}^{nj,oj}\widehat{x}_{t+1}^{oj}}{\widehat{P}_{t+1}^{nj}}\right)^{-\theta^j}\left(\widehat{A}_{t+1}^{oj}\right)^{\gamma^{oj}\theta^j} \tag{43}$$

$$X_{t+1}'^{nj} = \sum_{k=1}^{J}\gamma^{nk,nj}\sum_{\mathrm{O}=1}^{N}\frac{\pi_{t+1}'^{\mathrm{O}k,nk}X_{t+1}'^{\mathrm{O}k}}{1+\tau_{t+1}^{\mathrm{O}k,nk}}$$

$$
\begin{aligned}
&+ \quad \alpha^{nj}\left(\sum_{k=1}^{J}\sum_{s=1}^{3}\widehat{w}_{t+1}^{nks}\widehat{L}_{t+1}^{nks}w_t^{\prime nks}L_t^{\prime nks}\dot{w}_{t+1}^{nks}\dot{L}_{t+1}^{nks}+\widehat{r}_{t+1}^{n}\widehat{K}_{t+1}^{n}r_t^{\prime n}K_t^{\prime n}\dot{r}_{t+1}^{n}\dot{K}_{t+1}^{n}\right)\\
&+ \quad \alpha^{nj}\left(\sum_{k=1}^{J}\sum_{\text{o}=1}^{N}\tau_{t+1}^{nk,\text{o}k}\frac{\pi_{t+1}^{\prime nk,\text{o}k}X_{t+1}^{\prime nk}}{1+\tau_{t+1}^{nk,\text{o}k}}+\iota_{t+1}^{n}\sum_{k=1}^{J}\sum_{\text{o}=1}^{N}X_{t+1}^{\prime \text{o}k}\right) \qquad (44)
\end{aligned}
$$

$$
\widehat{w}_{t+1}^{nks}\widehat{L}_{t+1}^{nks}w_t^{\prime nks}L_t^{\prime nks}\dot{w}_{t+1}^{nks}\dot{L}_{t+1}^{nks} = \gamma_{t+1}^{\prime L,njs}\sum_{o=1}^{N}\frac{\pi_{t+1}^{\prime oj,nj}X_{t+1}^{\prime oj}}{1+\tau_{t+1}^{\prime oj,nj}}, \qquad s\in\{1,2,3\} \qquad (45)
$$

$$
\widehat{r}_{t+1}^{n}\widehat{K}_{t+1}^{n}r_t^{\prime n}K_t^{\prime n}\dot{r}_{t+1}^{n}\dot{K}_{t+1}^{n} = \sum_{j=1}^{J}\gamma_{t+1}^{\prime K,nj}\sum_{\text{o}=1}^{N}\frac{\pi_{t+1}^{\prime \text{o}j,nj}X_{t+1}^{\prime \text{o}j}}{1+\tau_{t+1}^{\prime \text{o}j,nj}} \qquad (46)
$$

$$
\widehat{P}_{t+1}^{n} = \prod_{j=1}^{J}\left(\widehat{P}_{t+1}^{nj}\right)^{\alpha^{nj}}, \qquad (47)
$$

where

$$
\begin{aligned}
\left(\widehat{\chi}_{t+1}^{njh}\right)^{1-\xi^{njh}} &= \frac{\gamma_t^{\prime L,nj3}\dot{\gamma}_{t+1}^{L,nj3}}{\gamma_t^{\prime L,njh}\dot{\gamma}_{t+1}^{L,njh}}\left(\widehat{w}_{t+1}^{nj3}\right)^{1-\xi^{njh}}+\frac{\gamma_t^{\prime K,nj}\dot{\gamma}_{t+1}^{K,nj}}{\gamma_t^{\prime L,njh}\dot{\gamma}_{t+1}^{L,njh}}\left(\widehat{r}_{t+1}^{n}\right)^{1-\xi^{njh}}\\
\left(\widehat{\chi}_{t+1}^{nj}\right)^{1-\xi^{nj}} &= \frac{\gamma_t^{\prime L,nj1}\dot{\gamma}_{t+1}^{L,nj1}}{\gamma^{nj}}\left(\widehat{w}_{t+1}^{nj1}\right)^{1-\xi^{nj}}+\frac{\gamma_t^{\prime L,nj2}\dot{\gamma}_{t+1}^{L,nj2}}{\gamma^{nj}}\left(\widehat{w}_{t+1}^{nj2}\right)^{1-\xi^{nj}}+\frac{\gamma_t^{\prime L,njh}\dot{\gamma}_{t+1}^{L,njh}}{\gamma^{nj}}\left(\widehat{\chi}_{t+1}^{njh}\right)^{1-\xi^{nj}}
\end{aligned}
$$

and the counterfactual cost shares of labor and capital inputs are given by:

$$
\begin{aligned}
\frac{\gamma_{t+1}^{\prime L,nj1}}{\gamma^{nj}} &= \frac{\gamma_t^{\prime L,nj1}\dot{\gamma}_{t+1}^{L,nj1}}{\gamma^{nj}}\frac{\left(\widehat{w}_{t+1}^{nj1}\right)^{1-\xi^{nj}}}{\left(\widehat{\chi}_{t+1}^{nj}\right)^{1-\xi^{nj}}}\\
\frac{\gamma_{t+1}^{\prime L,nj2}}{\gamma^{nj}} &= \frac{\gamma_t^{\prime L,nj2}\dot{\gamma}_{t+1}^{L,nj2}}{\gamma^{nj}}\frac{\left(\widehat{w}_{t+1}^{nj2}\right)^{1-\xi^{nj}}}{\left(\widehat{\chi}_{t+1}^{nj}\right)^{1-\xi^{nj}}}\\
\frac{\gamma_{t+1}^{\prime L,njh}}{\gamma^{nj}} &= \frac{\gamma_t^{\prime L,njh}\dot{\gamma}_{t+1}^{L,njh}}{\gamma^{nj}}\frac{\left(\widehat{\chi}_{t+1}^{njh}\right)^{1-\xi^{nj}}}{\left(\widehat{\chi}_{t+1}^{nj}\right)^{1-\xi^{nj}}}\\
\frac{\gamma_{t+1}^{\prime L,nj3}}{\gamma_{t+1}^{\prime L,njh}} &= \frac{\gamma_t^{\prime L,nj3}}{\gamma_t^{\prime L,njh}}\frac{\dot{\gamma}_{t+1}^{L,nj3}}{\dot{\gamma}_{t+1}^{L,njh}}\frac{\left(\widehat{w}_{t+1}^{nj3}\right)^{1-\xi^{njh}}}{\left(\widehat{\chi}_{t+1}^{njh}\right)^{1-\xi^{njh}}}\\
\frac{\gamma_{t+1}^{\prime K,nj}}{\gamma_{t+1}^{\prime L,njh}} &= \frac{\gamma_t^{\prime K,nj}}{\gamma_t^{\prime L,njh}}\frac{\dot{\gamma}_{t+1}^{K,nj}}{\dot{\gamma}_{t+1}^{L,njh}}\frac{\left(\widehat{r}_{t+1}^{n}\right)^{1-\xi^{njh}}}{\left(\widehat{\chi}_{t+1}^{njh}\right)^{1-\xi^{njh}}}.
\end{aligned}
$$

4 Calibration

This section provides a summary of the parameter values and data used in the quantitative analysis. Further details about the data sources and measurements are documented in Appendix A.

4.1 Trade, Tariffs, and Production Parameters

Data on trade shares ($\pi_t^{nj,oj}$), input-output coefficients ($\gamma^{nj,nk}$), value-added shares (γ^{nj}) and final demand expenditure shares (α^{nj}) were compiled based on the OECD TiVA ICIO Tables (2016 edition). We impute the skill shares ($\gamma_t^{L,njs}$) and capital shares ($\gamma_t^{K,nj}$) based on the World Input-Output (WIOD) Database Socioeconomic Account. We calibrate the two-tier CES production function parameters ($\xi^{njh} = 0.67$, $\xi^{nj} = 4$) following Krusell, Ohanian, José-Víctor, Ríos-Rull and Violante (2000) and Bils, Kaymak and Wu (2022). Data on economy-level aggregate capital stock were sourced from Penn World Table 10.1, deflated to the 1995 price level (based on the GDP deflator from World Bank, and from Directorate General of Budget, Accounting and Statistics for Taiwan). We follow Caliendo, Opromolla, Parro and Sforza (2023) and Cai, Caliendo, Parro and Xiang (2022), and adopt a capital depreciation rate of $\delta^K = 5\%$. We use tariff data ($\tau_t^{nj,oj}$) from the World Integrated Trade Solution (WITS) database. The trade elasticities $\{\theta^j\}$ at the sector level were taken from Caliendo and Parro (2015, Table A2, Column 1).[5]

In sum, for the quantitative analyses, we calibrate the model to 60 individual economies and a residual Rest-of-World (ROW), 22 sectors (primary plus 11 manufacturing sectors and 10 service sectors) and non-employment, three labor skill groups (low, middle, and high), and capital. Table A.1 explains the classification of the sectors, and Table A.2 provides the summary statistics for the key parameters and variables.

4.2 Labor Market Parameters and Sector-Skill Transition

For Taiwan, the low-skilled, middle-skilled, and high-skilled workers are defined as, respectively, those with highest education attainment less than or equal to junior high school; those with a highest education attainment equal to senior high school or vocational school diploma; and those with a highest education attainment equal to a college degree (bachelor,

[5]When a sector in our classification corresponds to multiple sectors in Caliendo and Parro (2015), we take the simple average of the elasticities of the matched sectors. We drop the extreme elasticity estimates of Caliendo and Parro (2015) for mining and quarrying, wood, and petroleum, before taking the average. For the service sectors, whose elasticities were not estimated in Caliendo and Parro (2015), we use a value of 10.

master or doctorate degree). We compile the data on the allocation of labor by sector-skill during the period 1995–2007 and on the transition statistics across sector-skill combinations at annual frequency, based on the *Manpower Utilization Quasi-longitudinal Data* from the Survey Research Data Archive (SRDA) of Academia Sinica, Taiwan.

For economies other than Taiwan, the dynamics of labor market transition is not explicitly studied, so the skill group definition only matters in measuring the shares of the three skill groups ($\gamma_t^{L,njs}$). These measures are compiled from the WIOD Socioeconomic Account as documented above. The skill groups in this case are defined according to each economy's underlying education system; but the criteria are generally equivalent in terms of the years of schooling, and in line with our definition of low-, middle-, and high-skilled workers.

We set the annual discount factor β at 0.97, à la Artuç and McLaren (2015) and Caliendo, Parro, Opromolla and Sforza (2021). We set the mortality rate for Taiwan at 0.6% for the period studied, which implies $\delta \backsimeq 0.994$.[6] We estimate the labor market transition elasticity (corresponding to $\beta\delta/\nu$ in the current setup), based on the 2-stage approach proposed by Artuç and McLaren (2015) but adapted for the utility function specified in equation (1).[7] Since the labor-market transition dynamics are only studied for the Taiwanese economy, we omit the economy superscript in this section. In particular, in the first stage we estimate by PPML the following sector-skill-transition equation:

$$L_t^{js,ki} = \exp\left(\psi_t^{js} + \lambda_t^{ki} - \rho^{js,ki}/\nu\right) + \varepsilon_t^{js,ki} \tag{48}$$

where $L_t^{js,ki}$ is the flow of workers switching from sector-skill combination js to combination ki, measured by $L_t^{js} \times \mu_t^{js,ki}$. It can be shown that $L_t^{js,ki}$ depends on origin-cell-specific fixed effects ψ_t^{js}, destination-cell-specific fixed effects λ_t^{ki}, and the transition cost $\rho^{js,ki}$, subject to measurement/sampling errors $\varepsilon_t^{js,ki}$, based on similar proofs as in Artuç and McLaren (2015). The transition cost function is empirically implemented in the current study as:

$$\begin{aligned} \rho^{js,ki} &= 0 \text{ if } k = j, i = s; \\ &= \rho_1^{s,i} \text{ if } k = j, i \neq s; \\ &= \rho_2^{j,k} \text{ if } k \neq j, i = s; \\ &= \rho_2^{j,k} + \rho_3^{s,i} \text{ if } k \neq j, i \neq s. \end{aligned} \tag{49}$$

[6] The mortality rate is available from the National Development Council, Taiwan, at `https://pop-proj.ndc.gov.tw/chart.aspx?c=1&uid=61&pid=60`. We take the average of the mortality rates across 1995–2007. The rate is the same up to three decimal points if instead we take the average of the mortality rates during 2001–2007.

[7] The original framework's utility function depends on wage income linearly. In the current context, we follow Caliendo, Dvorkin and Parro (2019) such that the per period utility function depends on $\ln C_t^{njs} = \ln w_t^{njs} - \ln P_t^n$.

where $\rho_1^{s,i}$ is the cost for workers to upgrade skill from s to i (from s=low-skill to i=middle-skill or from s=middle-skill to i=high-skill) in the scenario without sector switching; $\rho_2^{j,k}$ is the cost for workers to switch from sector j to sector k without skill upgrading; and $\rho_3^{s,i}$ is the cost for workers to upgrade skill from s to i (from s=low-skill to i=middle-skill or from s=middle-skill to i=high-skill) in the scenario with sector switching. This specification allows for the possibility that the cost of switching both sector and skill is different from the sum of the cost of switching sector and the cost of upgrading skill (i.e., that there may be some non-linearity in the cost of joint switching).

Furthermore, it can be shown using the Bellman equation (1) and the transition probability equation (3) that the following holds:

$$\phi_t^{js} = \zeta_t + \frac{\beta\delta}{\nu} \ln w_{t+1}^{js} + \varepsilon_t^{js} \tag{50}$$

where $\phi_t^{js} \equiv \lambda_t^{js} + \beta\delta\psi_{t+1}^{js} - \beta\delta \log\left(L_{t+1}^{js}\right)$ can be imputed given the first-stage estimates of the fixed effects ($\lambda_t^{js}, \psi_{t+1}^{js}$) and the observed labor allocation L_{t+1}^{js}, while $\zeta_t \equiv -\frac{\beta\delta}{\nu} V_{t+1}^{oo} + \frac{(\beta\delta)^2}{\nu} V_{t+2}^{oo}$ corresponds to the difference in the discounted expected utilities (V_{t+1}, V_{t+2}) for a chosen omitted sector-skill category (oo), and will be captured by time fixed effects. We estimate (50) by an IV regression, using two-period lagged values of the right-hand-side variable ($\ln w_{t+1}^{js}$) as instruments, as in Artuç and McLaren (2015). In addition to the baseline controls specified in (50), we also control for extra fixed effects: $\eta_{t+1}^{s} \equiv \eta_1^s + \eta_2^s \times t$, which correspond to the origin-skill fixed effects and origin-skill-specific time trends. This can be interpreted as non-pecuniary benefits associated with each skill category (not captured by market wages). This is in line with Artuç and McLaren (2015), by including controls for non-pecuniary benefits.[8]

The estimation results are reported in Table 7. In Stage 1, based on estimations of equation (48) and the switching-cost specification in equation (49), we find that the skill-upgrading cost is higher from low to middle skill than from middle to high skill, and both sets of skill-upgrading costs are lower when joint with sector switching. Figure 6 summarizes the sector-to-sector switching costs (origin-sectors in the rows and destination-sectors in the columns), where the magnitudes reported reflect the sector-switching costs ($\rho_2^{j,k}$) without skill upgrading. Overall, the switching costs are the largest to switch from service to manufacturing sectors, followed by the costs to switch from manufacturing to service sectors, and by the costs to switch across sectors within manufacturing and within services. Column (2) of Table 7 then reports the Stage-2 estimation results. The estimate of the labor market

[8]The utility function in (1) can be modified to include this extra term, without affecting the counterfactual analysis presented in Section 5. The counterfactual equilibrium conditions in Section 3.8 remain intact, except that the counterfactual utilities $\widehat{u}_{t+1}^{njs}$ in (36) need to be scaled by $\widehat{\vartheta}_{t+1}^{njs}$, where $\vartheta_{t+1}^{njs} = exp(\eta_{t+1}^{ns})$.

transition elasticity (corresponding to $\beta\delta/\nu$) is 0.731 and significant at 1%.[9] Given the values of β and δ (as indicated above in this section), this implies an estimate of $\nu \backsimeq 1.319$, which we will use in the quantitative analyses.

5 Quantitative Analysis of Taiwan's WTO Accession

In this section, we conduct counterfactual simulations to assess the quantitative effect of Taiwan's WTO accession on its labor markets. In particular, we examine how workers transit across sectors and skills in response to the changes in tariffs and trade, and the implied welfare effects of such changes on the local workers conditional on their sector-skill combinations. We also report the corresponding effects on the economy's capital dynamics and allocations across sectors. In this quantitative exercise, the baseline economy consists of the actual changes in fundamentals for 1995–2007 (the data period) and constant fundamentals after 2007. In the counterfactual economy, Taiwan's tariffs on imports and foreign tariffs on Taiwan's exports are set to their levels in 1995. We simulate the model for both the baseline and the counterfactual economy until year 2050. The effect for each period is calculated as the difference between the baseline economy (with WTO accession) and the counterfactual economy (without WTO accession). When reporting the cumulative effects on the variables of interest, we focus on the near-term effects for the period 1995–2020.[10] The implementation algorithm for the simulations is detailed in Online Appendix B.

5.1 Transition Dynamics in Taiwanese Labor Markets

We start by presenting the transition dynamics of the Taiwanese labor market during 1995–2050 in the baseline economy versus the counterfactual economy. Figure 7 summarizes the pattern by broad sector categories (the simulation is nonetheless conducted at the disaggregate sector level detailed in Section 4). It shows that Taiwan's accession to the WTO had negative effects on employment in the primary/services sector, but positive effects on employment in the manufacturing sector. In particular, up to 2020, primary sector's employment was lower as a result of WTO accession by 0.93% of the total population (measured as the sum of employed, unemployed, and not-in-labor-force, as elaborated in Appendix A.1). This is relative to an initial employment size of 9.28% of the total population in the sector in

[9] This annual elasticity estimate is larger than the implied quarterly elasticity (0.185) of Caliendo, Dvorkin and Parro (2019), and in the same order of magnitude as the annual elasticity estimate (0.50) of Caliendo, Parro, Opromolla and Sforza (2021).

[10] This disregards the longer-run effects on the variables of interest, where economic fundamentals may deviate substantially from the situation in 2007, the end of the data period.

1995. The corresponding figures for the services sector are a decrease of 1.37% relative to an initial employment size of 45.18%. Meanwhile, manufacturing employment shares increased substantially by 6.06% of the total population due to the WTO accession, compared to an initial employment size of 20.62%.

These effects are quantitatively large, in comparison with the literature such as CDP (with effect estimates of around $\pm 0.3\%$). In addition, the positive effect on manufacturing employment is far larger than the negative effects on primary and services employment combined, implying that the overall employment increased as a result of WTO accession during this period. Specifically, up to 2020, non-employment was lower due to the WTO accession by 3.76% of the total population. The larger quantitative effects compared to the existing literature (which focuses on developed economies such as the US) may be attributed to the export-oriented, small, and open nature of Taiwan's economy.

The labor reallocation effects quantified above are consistent with our priors. As set out in the stylized facts, Taiwan lowered tariffs on primary imports from other economies during this period, in exchange for reduced foreign tariffs on its manufacturing exports. Hence, Taiwanese farmers were hit with increased import competition from abroad, which led to labor transition out from the primary sector. In contrast, manufacturing sectors expanded significantly due to improved access to foreign markets. The services sector, although not directly affected by import competition, also saw a drop in its employment size. As we will document below, this overall effect masks considerable heterogeneous responses across sub-sectors and across skill groups in this sector.

We further decompose the employment dynamics by skill groups in Figure 8. The upper panel shows that the negative effect of WTO accession on primary employment was almost entirely driven by the low-skilled workers, which can be explained by the low-skill nature of the sector. The middle and lower panels show that the WTO accession has positive effects on the high-skill employment in both the manufacturing and services sectors (by about 2.20% and 0.63%, respectively, up to 2020). Although the WTO accession initially had positive effects on the middle-skill and low-skill employment in the manufacturing sector, the effects faded out in the long run. In contrast, the services sector saw a decline in both middle-skill and low-skill employment due to the WTO accession (with a larger negative effect on the low-skill employment). They dominated the positive effect on high-skill employment in the services sector, and contributed to the net drop in the sector's employment. Overall, the pattern indicates a trend to upgrade skills in both manufacturing and services sectors, while low-skill jobs were gradually replaced by high-skill employment.

5.2 Effects on Sectoral Employment Shares

In this section, we further break down the effects by disaggregate sectors and discuss the importance of key sectors. Figure 9 suggests that among the manufacturing sectors, the positive effect on employment due to Taiwan's WTO entry was mainly driven by the MCEE sectors (Machinery, Equipment; Computer, Electronics), whose employment increased by 1.94% of the total population (cf. 6.06% across all manufacturing sectors). This was followed by the PCPM sectors (Petroleum, Chemicals; Plastics, Rubber; Non-metallic Minerals; Basic & Fabricated Metals), whose employment increased by 1.72% of the total population. Thus, the pattern of comparative advantage tilted toward these two broad sectors that are more skill-intensive and capital-intensive in nature and that expanded the most in their exports among other sectors in the stylized facts.

Column (1) of Table 8 also reports the counterpart for key service sectors that experienced large changes in employment due to the WTO accession. Among the service sectors, employment in the "Other Business Services" sector (including activities such as R&D, law, accounting, business consulting, architecture, engineering, advertising and other business activities, cf. Table A.1) increased the most by 0.64% of the total population, followed by "Financial Intermediation" (by 0.38%). In contrast, employment in the "Wholesale, Retail," "Construction," and "Hotels, Restaurants" sectors decreased. Thus, the "Financial Intermediation" and "Other Business Services" sectors benefitted from the expansion of manufacturing sectors, plausibly through input-output linkages, since the biggest export expansions in manufacturing stemmed from the skill-intensive MCEE sectors, which tended to source from the business services sectors.

We further show how employment shares of different skill groups changed in individual manufacturing sectors in Figure 10. In terms of skill groups, the employment shares of high-skilled and middle-skilled workers grew the most in the MCEE and PCPM sectors among other manufacturing sectors. These sectors also had the largest overall employment gains, as discussed above, which suggests that when these sectors expanded due to export shock, they tended to hire more skilled workers. This growth in factor demand for skills had important implications for skill acquisitions during this period, as we will discuss in Section 6.2.

5.3 Effects on Capital Dynamics and Allocation

Figure 11 displays the capital dynamics for the three broad sectors with and without the WTO accession. Across the board, Taiwan's WTO accession has positive effects on its capital accumulation in the long run, and the impacts are quantitatively and proportionally more pronounced for the manufacturing sector. Up to 2020, the growth rate of capital stock in the manufacturing sector was higher by 244.11 percentage points as a result of WTO accession. Figure 12 further shows how the growth rates of capital stock in individual manufacturing sectors changed as a result of WTO accession by 2020. Again, the MCEE sectors (Computer, Electronics; Machinery, Equipment) experienced a disproportionately large boom in their capital accumulation, followed by a subset of the PCPM sectors (Basic & Fabricated Metals; Petroleum, Chemicals). This echoes the pattern on high-skill employment shares in Figure 10, where the same set of sectors experienced the largest gain in high-skilled employment shares due to the WTO accession. Thus, skill and capital have responded hand in hand to increased foreign market access brought about by Taiwan's WTO accession, and this was manifested especially strongly in MCEE sectors (Taiwan's sectors of comparative advantage).

Column (1) of Table 9 provides the detailed statistics corresponding to Figures 11–12, and also the counterpart for key service sectors highlighted in the previous section. Noticeably, "Wholesale, Retail", which sustained the largest negative employment effects due to the WTO accession (Table 8, Column (1)), also had the smallest extent of push to its capital accumulation among all sectors. Despite the large growth of capital in the primary sector reported in Table 9,[11] it should be reminded that this sector's capital accumulation is quantitatively negligible compared with the manufacturing and service sectors, as shown in Figure 11.

5.4 Welfare Effects on Taiwanese Workers and Capital Owners

Table 10 reports the welfare effect of WTO accession by Taiwan on Taiwanese workers over the period of 1995–2020. The welfare effect for a worker in location n of sector-skill-level js is measured in terms of changes in his/her total discounted consumption equivalent during the period:

$$\widehat{W}^{njs} = \sum_{t=1995}^{2020} (\beta\delta)^{t-1995} \ln\left(\frac{\widehat{\omega}_t^{njs}}{\left(\widehat{\mu}_t^{njs,njs}\right)^{\nu}}\right). \tag{51}$$

In particular, the change in welfare due to the WTO accession is given by the present discounted value of the expected change in real consumption and the change in the option value. The change in the option value is summarized by the change in the fraction of workers that are not reallocated, $\widehat{\mu}_t^{njs,njs}$, and the variance of the taste shocks ν. A higher $\widehat{\mu}_t^{njs,njs}$ implies lower welfare gain, as workers in the cell have lower expected gains from switching out of the current cell. The aggregate welfare effects across all sectors and skills are computed

[11]This could be understood as a shift in agriculture from labor-intensive to more capital-intensive operations due to the WTO accession.

using sector-skill labor value-added shares in 1995 as weights.

In the aggregate, Taiwanese workers experienced a 3.148% welfare gain during the period 1995–2020, as a result of Taiwan's WTO accession. This welfare effect is large in comparison with the findings of the literature based on similar analytical frameworks for different economies (Caliendo, Dvorkin and Parro, 2019; Caliendo, Parro, Opromolla and Sforza, 2021). We attribute this difference to the fact that Taiwan is a small and open export-oriented economy, and hence stood to gain more from multilateral trade liberalization relative to larger economies.

We also calculate the welfare effects specific to each skill group, using sector-skill labor value-added shares (conditional on each skill's labor value-added share) in 1995 as weights. Table 10 indicates that the aggregate welfare gains for low-, middle, and high-skilled workers are 2.270%, 2.753%, and 4.629%, respectively, with the high-skilled workers experiencing the largest welfare gains. We further decompose the welfare effects by the broad sector categories of primary/manufacturing/services, where the welfare effects of workers are weighted by sector-skill labor value-added shares and normalized by each broad sector's labor value-added share in 1995. Aligned with the pattern of effects on employment shares presented above, Taiwan's WTO entry led to the largest welfare gains for workers in manufacturing sectors (3.453%), followed by services sectors (3.084%), with the least gains for workers in the primary sectors (2.592%).

The welfare formula for the capital owner can be derived using Equations (7)–(9). As shown in Online Appendix B.3, the expected welfare effect for capital owners over the period is:

$$\widehat{W}^{nK} = \sum_{t=1996}^{2020} \beta^{t-1995} \ln \widehat{K}^{n}_{t+1}. \tag{52}$$

Table 11 indicates that capital owners benefitted from Taiwan's WTO accession, with a welfare gain of 2.697% over the period of 1995–2020. Together, the aggregate welfare effect across capital owners and workers of all sectors and skills, using value-added shares in 1995 as weights, is 2.992%.

6 Anatomy of the Effects of Taiwan's WTO Accession

6.1 The Role of China

In Section 2 on the stylized facts, we documented that China had a strong influence on the trade pattern of Taiwan during the period studied (1995–2007). China also entered the WTO at about the same time as Taiwan. In this section, we analyze three more counterfactual scenarios to assess the interaction of the Chinese economy with Taiwan in international markets. In the first scenario, we assess the effects of China's WTO accession on Taiwan's labor market dynamics: in the counterfactual, China's import tariffs and foreign tariffs on China's exports are rolled back to their levels in 1995. In the second scenario, we study the combined effects of WTO accession by both Taiwan and China: in the counterfactual, both Taiwan's and China's import tariffs and foreign tariffs on Taiwan's and China's exports are set to their levels in 1995. In the third scenario, we evaluate the effects of the tariff concessions between Taiwan and China during this period. In particular, (only) the two economies' tariffs imposed against each other's exports are returned to their 1995 levels in the counterfactual.

Table 8 reports the effects on the employment shares across sectors and skill types in the Taiwanese labor market under the alternative scenarios of tariff concessions. We have reported the simulation results for the benchmark case (WTO accession by Taiwan) in Column (1). Panel A (reporting effects at the broad sector level) indicates that WTO accession by Taiwan had larger positive effects on manufacturing employment and larger negative effects on Taiwan's primary/services sector employment, in comparison with bilateral tariff concessions between only Taiwan and China (in Column (4)). This suggests that additional tariff concessions offered by Taiwan to economies beyond China increased import competition in the primary sector. However, improved access to these other markets boosted Taiwan's manufacturing exports globally. The expanded trade liberalization, in turn, amplified the net negative effect on the service sector.

Next, comparing the results in Column (2) and Column (4), we find that the effects of WTO accession by China were more positive (negative) for the manufacturing (service) employment in Taiwan than bilateral tariff concessions between Taiwan and China. In general, the additional tariff concessions between China and the other economies in the scenario of WTO accession by China (relative to bilateral tariff concessions) could increase the market competition that Taiwanese exports faced in the Chinese market from the other economies, and in the foreign markets from China, hence a smaller positive push to the manufacturing sectors in Taiwan. However, the general-equilibrium positive income effect of increased openness in China could lead to increased imports by China in the primary/manufacturing sectors, and that could more than offset potential negative effects of trade diversion from Taiwan toward the other sources with China's WTO accession (compared to bilateral concessions). The results indicate that the second mechanism dominates for primary/manufacturing employment in Taiwan. Indeed, the effect on the primary sector employment turned from negative (in the scenario of bilateral concessions) to positive (with China's WTO accession).

In contrast, comparing Column (1) with the WTO accession by Taiwan, and Column (3) with the WTO accession by both Taiwan and China, we find the effects of Column (3) to be milder than Column (1) for manufacturing employment. The additional tariff reductions between China and the other economies in Column (3) compared to Column (1) created an additional "competition effect" for Taiwanese exports in the third countries and in China's local market. This appeared to dominate potential general-equilibrium positive income effects in China, and overall led to a dampened positive employment effect for manufacturing sectors in Taiwan. Thus, the additional effect of WTO accession by China on Taiwan's manufacturing employment depends on the initial state of Taiwan's trade openness (with concession with respect to China only, or with respect to all WTO members). However, again, China's multilateral tariff concessions appeared to have helped cushion the negative employment effect on the primary sector in Taiwan. Overall, bilateral tariff concessions quantitatively account for a dominant portion of the employment effects in Taiwan brought on by Taiwan's and/or China's WTO accession.

Panel B of Table 8 presents the employment effects for key sectors that experienced large employment effects identified in Section 5.2. The difference in effects on the manufacturing employment across scenarios (e.g., between 6.06% in Column (1) and 4.76% in Column (2)) can be almost entirely explained by those of "Computer, Electronics", "Basic & Fabricated Metals", and "Textiles, Leather, Footwear" combined. In particular, "Computer, Electronics" played a pivotal role. These findings reiterate the importance of key manufacturing sectors in determining the aggregate employment effects in the Taiwanese labor market. Among large service sectors, the negative employment effects tended to worsen with China's multilateral trade liberalization, as indicated by comparing Column (2) with Column (4), or Column (3) with Column (1). This echoes the pattern we observed for the service sector as a whole in Panel A.

Panel C of Table 8 reports the effects by skill type. The high-skilled workers experienced the largest positive employment effects, followed by middle-skilled workers, while the low-skilled workers experienced negative employment effects. This pattern holds across all four scenarios of tariff concessions studied. This reflects the general comparative advantage of Taiwan in skill-intensive sectors. The ranking of the quantitative effects across scenarios follows a regular pattern that tends to strengthen with Taiwan's multilateral liberalization and weaken with China's multilateral liberalization. That is, the effects on Taiwanese employment by skill type tend to be stronger with Taiwan's WTO accession (Column (1)) than bilateral tariff concessions (Column (4)), and with combined WTO accession by Taiwan and China (Column (3)) than accession by China (Column (2)). In contrast, the effects on Taiwanese employment by skill type tend to be weaker with China's WTO accession (Column

(2)) than bilateral concession (Column (4)), and with combined WTO accession by Taiwan and China (Column (3)) than accession by Taiwan (Column (1)).

Table 9 reports the corresponding effects on the capital growth rates in Taiwan under alternative scenarios of tariff concessions. Basically, the comparison across scenarios follows that of the labor market effects closely. For example, recall that the WTO accession by Taiwan had larger positive (negative) effects on the manufacturing (primary/services) employment than bilateral concession. Correspondingly, the capital stock accumulated faster (slower) in the manufacturing (primary/services) sector with the WTO accession by Taiwan than bilateral concession. This is also reflected by the much larger effects on capital growth rates in the key manufacturing sectors (Computer, Electronics; Machinery, Equipment; Basic & Fabricated Metals) with Taiwan's WTO accession than bilateral concession. Similarly, as reported above, China's multilateral trade liberalization relative to bilateral concession with Taiwan tended to magnify the positive employment effect on the manufacturing sector in Taiwan; however, starting with Taiwan's WTO accession, further WTO accession by China weakened the positive manufacturing employment effect in Taiwan. In both cases, the primary sector's employment losses in Taiwan were mitigated with China's multilateral liberalization. The effects on capital growth rates in the manufacturing/primary sectors follow exactly the same ranking as observed for the employment effects across these scenarios.

Table 10 summarizes the welfare effects on Taiwanese workers by skill type and sector, under alternative scenarios of tariff concessions. In particular, the welfare effects are stronger for high-skilled workers (than middle-skilled and low-skilled workers) and for manufacturing workers (than services and primary workers). Across skill types and broad sectors, the effects are most pronounced (and positive) in the scenario of WTO accession by Taiwan, followed by WTO accession by both, and then by the accession of China. Similarly, the positive effects are stronger with the WTO accession by Taiwan than its bilateral concessions with China, and further stronger than the WTO accession by China. The pattern of the welfare effects across scenarios mimics a pattern previously noted for skill share effects: that is, the welfare gains by Taiwan tends to strengthen with Taiwan's multilateral liberalization and weaken with China's multilateral liberalization. The exception is the primary sector, where workers in Taiwan could potentially benefit from China's further trade liberalization with the rest of the world (e.g., from bilateral concession to China's WTO accession, or from Taiwan's WTO accession to combined WTO accession by both).

Table 11 on the welfare effects of capital owners basically reflects the same pattern of rankings across scenarios as those for workers. Thus, the aggregate welfare effects inherit the same pattern of rankings, with the WTO accession by Taiwan implying the largest welfare gains for the economy (2.992%). It is worthwhile noting that bilateral tariff concessions with China accounted for a large bulk of the welfare gains (2.552%). This again reiterates the importance of the Chinese economy to Taiwan as its leading trading partner during the period of study.

6.2 The Roles of Skill Upgrading and Capital Accumulation

In this section, we demonstrate the relevance of the skill-upgrade mechanism in quantifying the employment effect of Taiwan's WTO accession. To do so, we generalize the model introduced in Section 3 to allow for time-varying sector-skill transition costs. This basically appends the expressions for the utility function u_t^{njs} by an extra term $\left(\varrho_t^{njs,nki}\right)^{-\frac{1}{\nu}} \equiv \left(e^{\rho_t^{njs,nki}}\right)^{-\frac{1}{\nu}}$, where $\rho_t^{njs,nki}$ indicates the time-varying sector-skill transition costs. This implies corresponding changes to $\dot{\mu}_{t+1}^{njs,nki}$ in (29) and $\dot{u}_{t+1}^{njs}$ in (30) such that:

$$
\begin{aligned}
\dot{\mu}_{t+1}^{njs,nki} =& \frac{\left(\dot{u}_{t+2}^{nki}\right)^{\frac{\beta\delta}{\nu}}\left(\dot{\varrho}_{t+1}^{njs,nki}\right)^{-\frac{1}{\nu}}}{\sum_{\mathrm{K}=0}^{J}\sum_{\mathrm{I}\geq s}^{3}\mu_t^{njs,n\mathrm{KI}}\left(\dot{u}_{t+2}^{n\mathrm{KI}}\right)^{\frac{\beta\delta}{\nu}}\left(\dot{\varrho}_{t+1}^{njs,n\mathrm{KI}}\right)^{-\frac{1}{\nu}}}, \\
\dot{u}_{t+1}^{njs} =& \dot{\omega}_{t+1}^{njs}\left[\sum_{\mathrm{K}=0}^{J}\sum_{\mathrm{I}\geq s}^{3}\mu_t^{njs,n\mathrm{KI}}\left(\dot{u}_{t+2}^{n\mathrm{KI}}\right)^{\frac{\beta\delta}{\nu}}\left(\dot{\varrho}_{t+1}^{njs,n\mathrm{KI}}\right)^{-\frac{1}{\nu}}\right]^{\nu}.
\end{aligned}
$$

Accordingly, $\hat{\mu}_{t+1}^{njs,nki}$ in (35) and $\hat{u}_{t+1}^{njs}$ in (36) are now appended such that:

$$
\begin{aligned}
\widehat{\mu}_{t+1}^{njs,nki} =& \frac{\left(\widehat{u}_{t+2}^{nki}\right)^{\frac{\beta\delta}{\nu}}\left(\widehat{\varrho}_{t+1}^{njs,nki}\right)^{-\frac{1}{\nu}}}{\sum_{\mathrm{K}=0}^{J}\sum_{\mathrm{I}\geq s}^{3}\mu_t^{\prime njs,n\mathrm{KI}}\dot{\mu}_{t+1}^{njs,n\mathrm{KI}}\left(\widehat{u}_{t+2}^{n\mathrm{KI}}\right)^{\frac{\beta\delta}{\nu}}\left(\widehat{\varrho}_{t+1}^{njs,n\mathrm{KI}}\right)^{-\frac{1}{\nu}}}, \\
\widehat{u}_{t+1}^{njs} =& \widehat{\omega}_{t+1}^{njs}\left[\sum_{\mathrm{K}=0}^{J}\sum_{\mathrm{I}\geq s}^{3}\mu_t^{\prime njs,n\mathrm{KI}}\dot{\mu}_{t+1}^{njs,n\mathrm{KI}}\left(\widehat{u}_{t+2}^{n\mathrm{KI}}\right)^{\frac{\beta\delta}{\nu}}\left(\widehat{\varrho}_{t+1}^{njs,n\mathrm{KI}}\right)^{-\frac{1}{\nu}}\right]^{\nu}.
\end{aligned}
$$

The sequential and counterfactual equilibrium conditions for the other variables are otherwise identical to the benchmark presented in Section 3.8. Online Appendix C provides the derivations.

With this extension, we conduct a counterfactual exercise where the cost of skill upgrading (from low to middle or from middle to high) is raised to a prohibitive level from 1996 onwards relative to 1995.[12] This quantitative exercise effectively shuts down the mechanism of transition across skill types over time. We then use the equilibrium path of changes from

[12]Specifically, the counterfactual ratios across periods of sector-skill transition costs $\widehat{\varrho}_t^{njs,nki}$ if involving skill upgrade are set to be e^{20} in 1996.

this exercise as the baseline. Conditional on this baseline, we roll back Taiwan's tariffs on imports and foreign tariffs on Taiwan's exports to their levels in 1995. Hence, we obtain a baseline where skill upgrading is absent, but WTO accession is present; and a counterfactual economy where both skill upgrading and WTO accession are eliminated. The difference between the two simulations then measures the quantitative effect of Taiwan's WTO accession in an environment where skill upgrading is prohibitive. This is then compared to the effect of Taiwan's WTO accession where the skill-upgrade mechanism is present (as reported in Section 5).

Figure 13 illustrates the results of this quantitative exercise by broad sectors and skill groups, where the effects are calculated for the period of 1995–2020. We find that the employment effects of WTO accession in the presence of skill upgrading are in general much more pronounced than the scenario where skill upgrading is absent. This suggests the existence of strong complementarity between skill upgrading and tariff concessions by Taiwan during the period studied. The difference between the two scenarios is quantitatively large, thus highlighting the importance of the supply-side adjustment mechanism. The inclusion of the skill-upgrade mechanism is also pivotal to the qualitative findings of employment effects across sectors. In particular, WTO accession by Taiwan tends to increase high-skilled employment in both manufacturing and service sectors when the skill-upgrade mechanism is present. In contrast, when skill upgrading is prohibitive, WTO accession increases the employment of high-skilled workers only in the manufacturing sector and decreases skilled employment in the service sector. To understand these findings, note that when skill upgrading is an option, workers upgrade their skills in response to the larger demand for skills from the manufacturing sector as a result of WTO accession. In the process, key service sectors also benefit from the input-output linkages and the access to the larger pool of skilled labor. In contrast, when skill upgrading is prohibitive, the supply-side adjustment is eliminated, which rules out inflows of new skilled workers. As a result, the WTO accession results in reallocation of skilled workers from the primary/service sectors (and non-employment) toward the expanding manufacturing sectors. Similarly, without skill upgrading, the expanded employment of middle-skilled workers by the manufacturing sector came at the cost of the primary/service sectors, which experienced enlarged losses in employment shares of such workers.

We further examine the employment effects by individual manufacturing sectors in Figure 14. Several patterns emerge. First, the gap between the two scenarios is proportionally very large for most of the manufacturing sectors. Without skill upgrading, most manufacturing sectors would experience very small increases in high-/middle-skilled employment. Second, the "Computer, Electronics" sector stands out in the sense that its skilled employment still increases substantially even when the skill-upgrade mechanism is eliminated. As suggested in the previous section, "Computer, Electronics" is the sector of comparative advantage in Taiwan. Thus, even when skill upgrading is inoperative, Taiwan's WTO accession still induces skilled labor to reallocate to the "Computer, Electronics" sector from the other non-manufacturing sectors. Third, because the difference in employment effects for the other manufacturing sectors (other than "Computer, Electronics") is particularly large, this implies that skill upgrading on the supply side helped increase skilled employment proportionally more in these sectors. In sum, the skill-upgrade mechanism allowed the supply side to respond to the increased demand for higher skills and helped mitigate the upward pressure on the skill premiums, such that manufacturing sectors across the board increased their employment of skilled workers. As discussed above, this increased supply of skilled labor also spilled over into the service industries. As a result, we observe significantly larger responses in employment following Taiwan's WTO accession.

Figure 15 reports the effects of Taiwan's WTO accession on the capital growth rates with and without skill upgrading. The pattern follows that for high-skilled workers in Figure 13 for broad sectors and Figure 14 for manufacturing subsectors closely. As observed above, the limited supply of skilled-workers in the scenario without skill upgrading led to a concentration of skilled workers in key manufacturing sectors (Computer, Electronics; Petroleum, Chemicals), away from services, following accession to the WTO. Due to skill-capital complementarity, capital tended to experience larger growth in sectors where skill-employment shares increased by more due to the WTO accession and smaller or negative growth in sectors where skill-employment shares increased by less or decreased. Thus, the skill-upgrade mechanism indirectly stimulated capital accumulation in Taiwan following its WTO accession, and enabled capital stock to grow across a wider spectrum of manufacturing and services sectors.

Next, we examine the role of capital accumulation, by comparing the effect of Taiwan's WTO accession in the benchmark setup with capital accumulation and in an alternative setup where the capital stock and its allocation are held fixed at the 1995 level. Figure 16 shows that employment in the manufacturing sector increased across all skill groups, regardless of whether capital accumulation is allowed. However, the presence of capital accumulation increased the share of high-skill employment in manufacturing while reducing it in the services sector. To understand this, recall that the WTO accession stimulated capital accumulation in both the manufacturing and services sectors, but the effects on the capital growth were more pronounced in the manufacturing than the services sector (cf. Figure 11 and Table 9). Thus, given skill-capital complementarity, the stronger (weaker) capital growth in manufacturing (services) attracted more (less) high-skill workers into the manufacturing (services) sector in the benchmark, relative to the scenario without capital accumulation.

We sum up our analysis by examining the importance of the skill-upgrade and capital accumulation mechanisms on welfare. Tables 10 and 11 indicate that in the scenario without the skill-upgrade mechanism, all welfare gains from the WTO accession (for workers, for capital owners, or in the aggregate) would be substantially muted compared to the benchmark. Thus, the skill-upgrade mechanism is crucial in driving the welfare gains of Taiwan from its WTO accession. In addition, the welfare effects across skill groups would become more unequal without the skill-upgrade mechanism (as there would arise a stronger redistribution effect in the case of fixed skill supply).

In the scenario without capital accumulation, the aggregate welfare gains from the WTO accession would be slightly lower than the benchmark, although the welfare gains for workers would be slightly higher. When capital accumulation is halted, individuals are not required to sacrifice consumption for investment. This positive effect largely offsets the negative impact of losing the capital growth channel on long-run welfare, resulting in welfare outcomes similar to the benchmark case. Note in addition that in the benchmark, the welfare gap between high-skill workers and the other two skill groups is larger compared to the constant capital case. This highlights that capital accumulation, accelerated by the WTO entry, disproportionately benefits high-skill workers due to skill-capital complementarity.

7 Conclusion

This paper studies the evolution of the Taiwanese labor markets (disaggregated by sectors and skills) during 1995–2007, a time when the Taiwanese import tariffs and other economies' tariffs against Taiwanese exports fell significantly due to Taiwan's accession to the WTO. We document a rich set of stylized facts on changes in tariffs, trade flows, labor market and capital dynamics of Taiwan during this period. Generalizing the framework of Caliendo, Dvorkin and Parro (2019), we allow for skill upgrading, capital accumulation and endogenous factor shares, and conduct quantitative analyses to examine the dynamic adjustments in Taiwanese workers' sector-skill choices during this period, due to Taiwan's WTO accession. The quantitative effects and qualitative patterns are compared with those of China's WTO accession, combined accession by both Taiwan and China, or bilateral tariff concessions between the two economies. We summarize the main takeaways as follows.

First and foremost, we find that Taiwan's accession to the WTO explains much of the observed patterns of Taiwan's trade and labor-market outcomes during this period, demonstrating the important roles played by tariff concessions. In turn, much of the impact can be attributed to the bilateral tariff concessions exchanged between Taiwan and China. This highlights the weight the Chinese economy has on the island. Notably, the China trade shock created a net positive employment effect for the Taiwanese manufacturing sector, which is a stark contrast with the existing literature that typically finds the China shock to hurt manufacturing jobs in other economies.

At the sector-skill level, the "star" manufacturing sectors (the MCEE sector in particular) basically drove the changes in trade and labor market patterns, and the effects spilled over to service sectors (mainly financial intermediation and other business services) through input-output linkages. The expanding sectors, the MCEE and business services sectors, also were the sectors that propelled the skill upgrading seen in both the data and counterfactual analyses. As a result, the high-skilled workers and the star manufacturing/service sectors enjoyed the most welfare gains from Taiwan's trade liberalization during 1995–2007. This is in contrast with the low-skilled workers and the primary sector, which suffered from increased import competition, lost employment shares, and enjoyed the smallest welfare gains. We also find that the WTO entry accelerated capital accumulation in both manufacturing and services, and much more so in manufacturing, driven by capital growth in the star sectors.

To highlight the importance of the skill-upgrade and capital accumulation mechanism, we re-evaluate the effects of Taiwan's WTO accession in the alternative setups where skill upgrading or capital accumulation is eliminated. Absent skill upgrading, the quantitative magnitudes of the employment and welfare effects would be substantially reduced, with the positive employment effects concentrated in the star sectors. This demonstrates the importance of the supply-side adjustment that responded to the increased demand for higher skills due to the trade shocks experienced by Taiwan during this period, and allowed the welfare gains to spill over to a broader spectrum of the economy.

By comparing the outcomes with and without capital accumulation, we find that capital accumulation amplified the increase in high-skill employment share in manufacturing but dampened that in services, driven by skill-capital complementarity. The aggregate welfare gains from the WTO entry do not differ significantly as a result of capital accumulation. However, capital accumulation widens the gap in welfare gains between high-skilled workers and the other workers.

The analytical framework can potentially be extended methodologically to address alternative policy questions of interest. For example, in the benchmark, jobs and skills are paired perfectly, such that a worker with a given skill level always does a job that requires exactly the skill level. Therefore, a high-skilled worker is always assigned to an occupation that requires a high skill level. In Online Appendix D, we generalize the model by allowing workers to undertake jobs with lower skill requirement than the worker's current skill level. The empirical implementation of the alternative framework, however, requires additional data and measurement of skill requirements for occupations in each sector and the mass of workers engaged in the corresponding occupations and sectors, in addition to the education attainments of workers and their sectors of employment. We leave these potential analyses for future research.

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A Data

A.1 Sector-Skill Movement in Taiwan

We construct the transition statistics across sector-skill combinations for the Taiwanese labor market in the period 1995–2007, based on the *Manpower Utilization Quasi-longitudinal Data* from the Survey Research Data Archive (SRDA), Academia Sinica, Taiwan. The dataset is further a compilation of the data gleaned from the *Manpower Utilization Survey* conducted by the Taiwanese Directorate General of Budget, Accounting and Statistics (DGBAS). Given the original surveys (in May) of two consecutive years, the SRDA performed matching of observations across years based on household IDs and individual characteristics. About 50% of the individuals remain in the survey sample across every two consecutive years. Hence, the compiled survey sample by the SRDA is quasi-longitudinal. We combine the SRDA data for 1995–1996, 1996–1997, . . . , and 2006–2007, to obtain the transition matrix for the whole period.

The *Manpower Utilization Survey* samples all members above age 15 in the surveyed households, and provides detailed information on the education attainment, sector employed, and sampling weight of each observation. The quasi-longitudinal data thus allow us to trace the above characteristics for each individual surveyed across every two consecutive years. The quasi-longitudinal dataset contains approximately 25000 observations (individuals) in each two-year cycle.

We characterize the skill level of an individual by his/her education attainment. The education attainment in the data is defined by the highest level of education achieved, including illiteracy, self-educated, primary, junior high, senior high and vocational, and college (bachelor, master and doctorate degrees). Because primary and junior high education is compulsory in Taiwan, we group these two levels together with illiteracy and self-educated as low-skill attainment. We label the senior high and vocational diplomas as middle-skill attainment, and college degrees as high-skill attainment.

We screen the observations and classify them into "not-in-our-sample" (NIOS), "not-in-labor-force" (NILF), unemployed, and employed as follows.

(1) Based on the survey question "work_t", classify as "not-in-our-sample" (NIOS) the following respondents who:

  (1a) reported 9, 10, and 11 before 2007. This corresponds to "Old (65+) and Disabled", "Military Personnel and Jailed", and "Others".

  (1b) reported 9, 10, 11, 12, and 13 after 2007. This corresponds to "Old (65+) and Disabled", "Retired", "Major Illness", "Military Personnel, Prisoners, and Missing

Population", and "Others".

(2) Based on the survey question "work_t" and "age_t", classify as NIOS the respondents who reported 7 (students) to the survey question "work_t", and reported less than or equal to 22 to the survey question "age_t", where age 22 is the typical age when a university student obtains a bachelor's degree in Taiwan.

(3) For remaining observations, based on the survey question "primaryworker_t", classify the respondents as unemployed (unemp) if their response to the question is not "NA". The rationale for using this question to identify unemployment is because of the questionnaire design. This question is the follow-up question after the main question "How long have you been searching for a job, or waiting to return to work, while being jobless". Therefore, the sub-question "primaryworker_t" is answered specifically by unemployed respondents. This is also the official way that DGBAS identifies the unemployed.

(4) For remaining observations, based on the survey question "workstus_t", classify respondents as "not-in-labor-force" (NILF) if the response is "NA". Also classify respondents as NILF if the response to "workstus_t" is 5 (unpaid home worker) and the reported work hours are below 15 hours per week, based on the response to "workhour_t" (for respondents working full time as unpaid home worker) or the response to "a8_1b_t" (for respondents working part time as unpaid home worker).

(5) The remaining respondents are classified as employed. Based on the survey question "indu_t", identify the respondent's sector of employment.

We drop the NIOS observations (which correspond to mainly those above age 65, non-civilians, and those reporting to be students and with an age below 22) from the study. This is because they do not reflect the model's target demographic group that actively makes the sector-skill switching decisions.[13] Note however that respondents who report to be working and have an age below 22 are included in the sample (they correspond to either low- or middle-skilled workers, without a college degree). For respondents who report to be students and with an age above 22, we keep them in the study as part of the NILF: they correspond to postgraduate students (who have the potential to enter the labor force), or those who return from the labor force to study. We then combine the NILF and the unemployed as one category under "non-employment". These are individuals who could potentially choose

[13]Theoretically, we could have kept the respondents who are currently students with an age below 22 but had worked in the past (thus having made the sector-skill switching choice). However, the questionnaire design does not allow us to identify this subset of students.

to switch to sectors of employment. We harmonize the Taiwanese sector classification (ROC SIC) used by the DGBAS with ISIC Rev 3. The concordance is provided in Table A.1. The quasi-longitudinal data by tracking individuals in every two consecutive years allow us to construct the transition matrix of sector-skill movement at annual frequency. We weight each observation by the sampling weight variable (attached to each observation).

A.2 Tariffs

The tariff data were downloaded from the World Integrated Trade Solution (WITS) database at the HS 6-digit level for the years 1995–2007. In particular, we select the effectively applied Ad Valorem Equivalent (AVE) tariff rates. We then compute the weighted average tariff rates for the list of sectors and countries reported in the analysis, using the WITS trade value as weights. If the tariff rate for an economy-sector observation is missing for a particular year, we fill in the missing value by using the tariff rate in the subsequent year. If the value in the subsequent year is also not available, we fill in the missing value using the tariff rate of the previous year.

A.3 Trade Flows

The trade data are taken from the OECD TiVA ICIO Tables (2016 edition). We aggregate the intermediates trade, the final goods trade, and the discrepancy term to obtain a total trade flow measure at the origin-economy-destination-economy-sector level. The discrepancy term is reported at the origin-economy-sector level. We distribute this term equally among the destination economies.

A.4 Value Added Share, Intermediate Input Shares, and Final Demand Expenditure Shares

The data on value added, gross output, input-output linkages, and final demand are from the same source as the trade data. The value-added share is computed as the ratio of value added in gross output at the economy-sector level based on the initial values in 1995. The intermediate input shares are constructed as the share of intermediate trade flow from an origin-sector relative to the gross output of a destination-sector in each economy in 1995. The final demand expenditure share at the economy-sector level is computed using the ratio of total final demand expenditure on each sector relative to the aggregate expenditure of each economy in 1995.

A.5 Share of Capital and Labor Compensation by Skill Group

Our simulations also require data on the initial shares of capital and labor compensation by skill type in gross output. Ideally, we would want to use the OECD TiVA ICIO Tables, the same source as for the value added and gross output. However, these statistics are not available in TiVA. Thus, we collect them from the World Input-Output (WIOD) Database Socioeconomic Account (2013 edition). First, we use the variables, "CAP" (capital compensation) and "VA" (gross value added at current basic prices), to compute the share of capital in value added at the economy-sector level in 1995. Combined with the share of value added in gross output from TiVA, this allows us to construct the share of capital in gross output. Next, WIOD (2013 edition) provides the statistics, "LABHS", "LABMS", and "LABLS", on the shares of high/middle/low-skilled labor compensation in total labor compensation. We take the initial values in 1995 at the economy-sector-skill level. This, when combined with the labor share in value added (i.e., one minus the capital share in value added), and the value-added share in gross output, enables us to construct the three skill shares in gross output. For economies in our study that are not covered individually by WIOD, we proxy their shares using the average of the 40 economies in WIOD. Taiwan is included individually as an economy in WIOD.

A.6 Mortality Rate

We obtain the information on Taiwanese mortality rate by using the statistics reported by the Taiwanese National Development Council.[14] In particular, we compute the time-series average over the years 1995–2007, which gives a mortality rate of 0.6%.

A.7 Economy and Sector Grouping

We organize our list of economies and sectors based on the TiVA ICIO Tables (2016 edition), which include 64 economies (63 individual economies and a Rest-of-World entity) and 34 industries. Due to data constraints/discrepancies in terms of classifications and coverage for tariffs, trade, and labor market data, we use a more aggregated grouping of economies and sectors.

First, we combine Belgium and Luxembourg as an entity, and merge Singapore and Hong Kong into the ROW. This leads to a set of 61 economies (60 individual economies and a ROW). In particular, the 61 economies are: 1. ARG Argentina; 2. AUS Australia; 3. AUT Austria; 4. BEL-LUX Belgium-Luxembourg; 5. BGR Bulgaria; 6. BRA Brazil; 7. BRN

[14] `https://pop-proj.ndc.gov.tw/chart.aspx?c=1&uid=61&pid=60`.

Brunei; 8. CAN Canada; 9. CHE Switzerland; 10. CHL Chile; 11. CHN China; 12. COL Colombia; 13. CRI Costa Rica; 14. CYP Cyprus; 15. CZE Czech Republic; 16. DEU Germany; 17. DNK Denmark; 18. ESP Spain; 19. EST Estonia; 20. FIN Finland; 21. FRA France; 22. GBR United Kingdom; 23. GRC Greece; 24. HRV Croatia; 25. HUN Hungary; 26. IDN Indonesia; 27. IND India; 28. IRL Ireland; 29. ISL Iceland; 30. ISR Israel; 31. ITA Italy; 32. JPN Japan; 33. KHM Cambodia; 34. KOR South Korea; 35. LTU Lithuania; 36. LVA Latvia; 37. MAR Morocco; 38. MEX Mexico; 39. MLT Malta; 40. MYS Malaysia; 41. NLD Netherlands; 42. NOR Norway; 43. NZL New Zealand; 44. PER Peru; 45. PHL Philippines; 46. POL Poland; 47. PRT Portugal; 48. ROU Romania; 49. ROW Rest of the World; 50. RUS Russia; 51. SAU Saudi Arabia; 52. SVK Slovakia; 53. SVN Slovenia; 54. SWE Sweden; 55. THA Thailand; 56. TUN Tunisia; 57. TUR Turkey; 58. TWN Taiwan; 59. USA United States; 60. VNM Vietnam; 61. ZAF South Africa.

We then combine 34 industries into 22 sectors. The concordance is documented in Table A.1. In particular, we combine c01t05 and c10t14; c20 and c21t22; c23 and c24; and c71 and c73t74. These sets of 61 economies and 22 sectors are used in our quantitative analyses.

For reporting of the stylized facts, we use larger groupings of economies and sectors to reduce the dimensionality in the figures. The trade flows are aggregated into major economies and regions in the world, including ASEAN+3, China, European Union, Japan, Korea, Latin America, Taiwan, United States, and a residual Rest-of-World. The group ASEAN+3 includes TiVA economies that were ASEAN members in 2007, in addition to three Indo-Pacific economies (India, Australia and New Zealand). European Union includes TiVA economies that were members of the EU in 2007. We further group the 22 sectors into 12 clusters. Table A.1's footnote provides the details of the grouping.

A.8 Dispersion of Productivity

The trade elasticities (corresponding to the parameter values characterizing the dispersion of productivity) at the sector level are taken from Caliendo and Parro (2015, Table A2, Column 1). When a sector in our classification corresponds to multiple sectors in Caliendo and Parro (2015), we take the simple average of the elasticities of the matched sectors. We drop the extreme elasticity estimates of Caliendo and Parro (2015) for mining and quarrying, wood, and petroleum, before taking the average. For the service sectors, whose elasticities were not estimated in Caliendo and Parro (2015), we use a value of 10.

Table A.2 provides the summary statistics for the key variables/parameters.

Table 1: Changes in tariffs on Taiwanese imports and exports (1995–2007)

Year	1995–2001		2002–2007	
Sector	Primary	Manufacturing	Primary	Manufacturing
Foreign Tariffs on Taiwan's Exports	0.07%	−2.54%	−3.10%	−1.75%
Taiwan's Import Tariffs	−0.42%	−1.25%	−4.42%	−1.31%

Notes: The table reports the changes (in percentage points) in average tariffs (across products and trading partners of Taiwan) in the primary and manufacturing sectors, before and after its WTO accession. Ad-valorem equivalent tariff rates are obtained from the WITS database. The average tariff rates are computed across 6-digit HS products in the primary and manufacturing sectors, respectively, weighted by the corresponding WITS trade value. Trading partners include all economies available in the WITS database. The 6-digit HS codes are first concorded to the 2-digit ISIC Rev.3 industries, and are then aggregated to the primary and manufacturing sectors. The primary sector includes 2-digit ISIC Rev.3 industries of 01–14. The manufacturing sector includes 2-digit ISIC Rev.3 industries of 15–37. See Table A.1 for details.

Table 2: Changes in Taiwanese exports and imports by sector from 1995 to 2007

Panel A: Export by Sector (1995 Million USD), 1995 and 2007

Sector	Export '95	Share '95	Export '07	Share '07	Growth	ΔExport	Contribution
Primary Sector	496	0.4%	910	0.3%	83.3%	413	0.2%
Food, Beverages, Tobacco	3,059	2.5%	2,347	0.7%	−23.3%	−711	−0.3%
Textiles, Wood, Paper	12,938	10.5%	10,635	3.3%	−17.8%	−2,303	−1.1%
PCPM	22,598	18.4%	85,528	26.1%	278.5%	62,929	30.8%
MCEE	46,060	37.5%	145,874	44.6%	216.7%	99,814	48.9%
Motor, Transport Equipment	9,857	8.0%	12,177	3.7%	23.5%	2,319	1.1%
Electricity, Water, Gas	0	0.0%	9	0.0%	-	9	0.0%
Construction	73	0.1%	276	0.1%	279.6%	203	0.1%
Wholesale, Retail, Hotels, Restaurants	18,391	15.0%	42,722	13.1%	132.3%	24,331	11.9%
Transport, Storage	5,211	4.2%	16,739	5.1%	221.2%	11,528	5.6%
Business Services	4,246	3.5%	9,998	3.1%	135.5%	5,752	2.8%
Total	122,929	100.0%	327,212	100.0%	166.2%	204,283	100.0%

Panel B: Import by Sector (1995 Million USD), 1995 and 2007

	Import '95	Share '95	Import '07	Share '07	Growth	ΔImport	Contribution
Primary Sector	8,365	7.0%	33,200	14.9%	296.9%	24,835	24.1%
Food, Beverages, Tobacco	3,243	2.7%	4,112	1.8%	26.8%	870	0.8%
Textiles, Wood, Paper	6,413	5.4%	5,552	2.5%	−13.4%	−861	−0.8%
PCPM	27,540	23.1%	56,809	25.6%	106.3%	29,269	28.4%
MCEE	30,271	25.4%	61,173	27.5%	102.1%	30,901	30.0%
Motor, Transport Equipment	6,776	5.7%	6,159	2.8%	−9.1%	−616	−0.6%
Electricity, Water, Gas	75	0.1%	42	0.0%	−43.7%	−33	0.0%
Construction	238	0.2%	287	0.1%	20.3%	48	0.0%
Wholesale, Retail, Hotels, Restaurants	19,611	16.5%	29,034	13.1%	48.1%	9,423	9.1%
Transport, Storage	12,507	10.5%	18,339	8.2%	46.6%	5,832	5.7%
Business Services	4,104	3.4%	7,600	3.4%	85.2%	3,496	3.4%
Total	119,142	100.0%	222,306	100.0%	86.6%	103,164	100.0%

Notes: Trade data are from the OECD TiVA ICIO Tables (2016 edition). Trading partners include all economy entities in TiVA. Sectors for this table are defined at a more aggregate level than used in the quantitative exercises to sharpen the broad picture. See Table A.1 and its footnote for the sector definitions. "Export" and "Import" columns are deflated by the respective "export price index" and "import price index" for each year, so that all trade flows are converted to 1995 price level in millions of USD. The export and import price indices are obtained from the Taiwanese Directorate General of Budget, Accounting and Statistics (DGBAS). The "Share" columns indicate the sectoral export/import share for each year. The "Growth" columns measure the percentage changes in exports/imports from 1995 to 2007. The "ΔExport/ΔImport" columns measure the level changes in exports/imports from 1995 to 2007. The "Contribution" columns measure the sectoral contribution to the overall export/import growth.

Table 3: Changes in MCEE exports and imports by trading partner from 1995 to 2007

Panel A: MCEE Export by Destination (1995 Million USD), 1995 and 2007

	Export '95	Share '95	Export '07	Share '07	Growth	ΔExport	Contribution
China	3,763	8.2%	70,797	48.5%	1,781.6%	67,034	67.2%
European Union	8,422	18.3%	16,157	11.1%	91.9%	7,735	7.7%
Indo-Pacific	6,047	13.1%	11,877	8.1%	96.4%	5,831	5.8%
Japan	4,772	10.4%	9,376	6.4%	96.5%	4,604	4.6%
Korea	1,135	2.5%	6,005	4.1%	428.9%	4,869	4.9%
Latin America	953	2.1%	5,700	3.9%	498.2%	4,747	4.8%
United States	15,870	34.5%	17,644	12.1%	11.2%	1,774	1.8%
ROW	5,099	11.1%	8,319	5.7%	63.1%	3,219	3.2%
Total	46,060	100.0%	145,874	100.0%	216.7%	99,814	100.0%

Panel B: MCEE Import by Origin (1995 Million USD), 1995 and 2007

	Import '95	Share '95	Import '07	Share '07	Growth	ΔImport	Contribution
China	429	1.4%	12,920	21.1%	2,910.2%	12,491	40.4%
European Union	4,985	16.5%	6,463	10.6%	29.6%	1,478	4.8%
Indo-Pacific	3,391	11.2%	5,572	9.1%	64.3%	2,181	7.1%
Japan	12,515	41.3%	15,669	25.6%	25.2%	3,154	10.2%
Korea	1,942	6.4%	6,444	10.5%	231.8%	4,502	14.6%
Latin America	228	0.8%	339	0.6%	48.8%	111	0.4%
United States	5,680	18.8%	8,953	14.6%	57.6%	3,273	10.6%
ROW	1,101	3.6%	4,812	7.9%	337.0%	3,711	12.0%
Total	30,271	100.0%	61,173	100.0%	102.1%	30,901	100.0%

Notes: Trade data are from the OECD TiVA ICIO Tables (2016 edition). Trading partners include all economy entities in TiVA. "ROW" here refers to the residual economies not covered by the other groups reported. European Union includes all TiVA economies that were members of the EU in 2007. ASEAN+3 includes (a) all TiVA economies that were members of the ASEAN in 2007; and (b) India, Australia, and New Zealand. "Export" and "Import" columns are deflated by the respective "export price index" and "import price index" for each year, so that all trade flows are converted to 1995 price level in millions of USD. The export and import price indices are obtained from the Taiwanese Directorate General of Budget, Accounting and Statistics (DGBAS). The "Share" columns indicate the sectoral export/import share for each year. The "Growth" columns measure the percentage changes in exports/imports from 1995 to 2007. The "ΔExport/ΔImport" columns measure the level changes in exports/imports from 1995 to 2007. The "Contribution" columns measure the country's contribution to the overall export/import growth in MCEE.

Table 4: Changes in PCPM exports and imports by trading partner from 1995 to 2007

Panel A: PCPM Export by Destination (1995 Million USD), 1995 and 2007

	Export '95	Share '95	Export '07	Share '07	Growth	ΔExport	Contribution
China	3,828	16.9%	29,212	34.2%	663.0%	25,383	40.3%
European Union	2,567	11.4%	7,679	9.0%	199.2%	5,113	8.1%
Indo-Pacific	4,902	21.7%	14,912	17.4%	204.2%	10,010	15.9%
Japan	2,262	10.0%	4,795	5.6%	111.9%	2,532	4.0%
Korea	1,064	4.7%	2,850	3.3%	167.9%	1,786	2.8%
Latin America	429	1.9%	2,309	2.7%	438.2%	1,880	3.0%
United States	3,845	17.0%	10,765	12.6%	180.0%	6,920	11.0%
ROW	3,701	16.4%	13,006	15.2%	251.4%	9,305	14.8%
Total	22,598	100.0%	85,528	100.0%	278.5%	62,929	100.0%

Panel B: PCPM Import by Origin (1995 Million USD), 1995 and 2007

	Import '95	Share '95	Import '07	Share '07	Growth	ΔImport	Contribution
China	1,092	4.0%	6,851	12.1%	527.4%	5,759	19.7%
European Union	4,311	15.7%	5,438	9.6%	26.1%	1,127	3.8%
Indo-Pacific	2,950	10.7%	9,304	16.4%	215.5%	6,355	21.7%
Japan	8,019	29.1%	13,383	23.6%	66.9%	5,364	18.3%
Korea	1,381	5.0%	4,345	7.6%	214.6%	2,964	10.1%
Latin America	1,227	4.5%	2,092	3.7%	70.5%	865	3.0%
United States	4,283	15.6%	4,922	8.7%	14.9%	638	2.2%
ROW	4,277	15.5%	10,474	18.4%	144.9%	6,198	21.2%
Total	27,540	100.0%	56,809	100.0%	106.3%	29,269	100.0%

Notes: Trade data are from the OECD TiVA ICIO Tables (2016 edition). Trading partners include all economy entities in TiVA. "ROW" here refers to the residual economies not covered by the other groups reported. European Union includes all TiVA economies that were members of the EU in 2007. ASEAN+3 includes (a) all TiVA economies that were members of the ASEAN in 2007; and (b) India, Australia, and New Zealand. "Export" and "Import" columns are deflated by the respective "export price index" and "import price index" for each year, so that all trade flows are converted to 1995 price level in millions of USD. The export and import price indices are obtained from the Taiwanese Directorate General of Budget, Accounting and Statistics (DGBAS). The "Share" columns indicate the sectoral export/import share for each year. The "Growth" columns measure the percentage changes in exports/imports from 1995 to 2007. The "ΔExport/ΔImport" columns measure the level changes in exports/imports from 1995 to 2007. The "Contribution" columns measure the country's contribution to the overall export/import growth in PCPM.

Table 5: Labor transition across sectors in Taiwan, 1995–2007

Sectors	From/To	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	School	'95%	'07%	Δ in %
Primary Sector	(1)	85.9	0.4	0.6	0.9	0.3	0.3	0.0	2.4	2.1	0.4	1.5	5.2	7.2	9.3	3.9	−5.3
Food, Beverages, Tobacco	(2)	1.8	77.2	0.7	1.6	1.3	0.3	0.0	0.6	8.5	0.7	1.9	5.4	10.9	1.1	1.1	0.0
Textiles, Wood, Paper	(3)	0.5	0.2	80.7	2.5	1.3	0.8	0.0	0.4	2.9	0.4	2.3	7.9	10.6	5.4	3.4	−1.9
Petroleum, Chemicals, Plastics, Metals	(4)	0.8	0.4	1.7	80.2	4.3	1.6	0.0	1.6	2.5	0.4	1.3	5.2	11.0	6.7	6.9	+0.2
Machinery, Computer, Electronics & Electrical	(5)	0.2	0.2	0.7	3.8	82.7	1.1	0.0	0.7	3.0	0.2	2.1	5.3	12.5	5.3	8.7	+3.5
Motor, Transport Equipment	(6)	0.8	0.3	1.8	4.8	3.9	75.8	0.0	1.1	3.1	0.7	1.7	5.9	10.9	2.2	2.1	0.0
Electricity, Water, Gas	(7)	0.1	0.0	0.1	0.6	0.5	0.1	92.1	1.9	1.7	0.2	1.8	0.9	13.5	0.3	0.3	−0.1
Construction	(8)	2.2	0.1	0.4	1.9	1.2	0.5	0.1	81.3	2.8	0.7	2.8	6.1	10.0	8.3	6.6	−1.7
Wholesale, Retail, Hotels, Restaurants	(9)	0.7	0.6	0.6	1.0	1.3	0.4	0.0	0.8	84.4	0.5	3.3	6.4	11.2	15.4	18.3	+2.9
Transport, Storage	(10)	0.9	0.2	0.3	1.0	0.6	0.4	0.1	1.0	2.8	86.9	2.6	3.2	11.3	3.2	3.0	−0.2
Business Services	(11)	0.3	0.1	0.5	0.4	0.9	0.2	0.0	0.9	2.8	0.4	88.8	4.7	13.5	17.9	22.5	+4.6
Non-employment	(12)	1.2	0.3	1.2	1.3	1.9	0.4	0.0	1.6	5.4	0.5	5.0	81.3	9.6	24.9	23.1	−1.8

Notes: Statistics are computed based on the *Manpower Utilization Quasi-longitudinal Data* from 1995 to 2007. The numbers reported are time-series-average transition rates in percentage during the period 1995–2007, measuring the proportion of labor transitioning out from a row-origin sector into a column-destination sector during a year. The "School" column measures the average years of schooling in each sector for the period 1995–2007. The columns labeled "'95%" and "'07%" measure the employment share of each sector in years 1995 and 2007, respectively. The column labeled "Δ in %" represents the change in employment share for each sector during the specified time period (in percentage points). The top five destination cells of each row-origin sector are highlighted in color. The cells highlighted in blue are the diagonal cells, which measure the proportions of labor that stay in the same sector. The cells highlighted in yellow are the cells that measure the proportions of labor that transit into a different sector among the top four destinations. See Table A.1 and its footnote for the sector definitions, and Table A.3 for the employment shares across sectors and skill types of the Taiwanese labor market in 1995.

Table 6: Changes in capital stock by sector

End-of-Year Capital Stock by Sector (1995 Million New Taiwan Dollar), 1996 and 2006

Sector	Stock '96	Share '96	Stock '06	Share '06	Growth	ΔStock	Contribution
Primary	31	0.2%	18	0.1%	-42.3%	-13	-0.1%
Food, Beverages, Tobacco	452	3.0%	462	1.9%	2.1%	10	0.1%
Textiles, Wood, Paper	778	5.2%	607	2.4%	-22.0%	-172	-1.7%
PCPM	2,120	14.3%	2,690	10.8%	26.9%	570	5.7%
MCEE	1,153	7.8%	3,919	15.8%	240.0%	2,767	27.8%
Motor, Transport Equipment	373	2.5%	478	1.9%	28.2%	105	1.1%
Electricity, Water, Gas	1,055	7.1%	1,689	6.8%	60.0%	633	6.4%
Construction	670	4.5%	636	2.6%	-5.0%	-34	-0.3%
Wholesale, Retail, Hotels, Restaurants	4,058	27.3%	5,120	20.6%	26.2%	1,062	10.7%
Transport, Storage	1,033	7.0%	3,500	14.1%	238.8%	2,467	24.8%
Business Services	3,138	21.1%	5,690	22.9%	81.3%	2,552	25.7%
Total	14,861	100.0%	24,809	100.0%	66.9%	9,947	100.0%

Notes: The capital stock data are compiled based on plant-level census, the *Industry, Commerce and Service Census of Taiwan*, conducted for all firms in mining, manufacturing and services sectors in every 5 years by the Taiwanese Directorate General of Budget, Accounting and Statistics (DGBAS). We use the censuses of 1996 and 2006, the nearest years to the beginning and the end of our study period. The census provides the plant-level end-of-year fixed asset value. The "Share" columns indicate the sectoral capital stock share for each year. The "Growth" column measures the percentage changes in capital stock between 1996 to 2006. The "ΔStock" column measures the level changes in capital stock between 1996 to 2006. The "Contribution" column measures the sectoral contribution to the overall capital stock growth. We first concord the plant-level census data available at ROC SIC 4-digit level to 2-digit ISIC Rev.3 sectors. We then aggregate further the 2-digit ISIC Rev.3 sectors to the sectors shown in the table. See Table A.1 and its footnote for the sector definitions. Note that the censuses were compiled by the DGBAS in the year after the census year, and follow the ROC SIC Rev.6 and 8 (applicable in year 1997 and 2007, respectively). Note that the census does not cover agriculture, hunting, forestry and fishing; thus, the Primary sector includes only the mining sector.

Table 7: Estimation of labor market transition elasticity $\beta\delta/\nu$

	(1) Stage 1 Estimation $L_t^{js,ki}$		(2) Stage 2 Estimation ϕ_t^{js}
$\rho_1^{low,mid}$	5.198***	$\ln w_{t+1}^{js}$	**0.731***
	(0.129)		(0.269)
$\rho_1^{mid,high}$	4.297***	$\eta_2^{middle} \times t$	-0.021
	(0.152)		(0.027)
$\rho_3^{low,mid}$	4.099***	$\eta_2^{high} \times t$	-0.029
	(0.121)		(0.027)
$\rho_3^{mid,high}$	2.999***		
	(0.136)		
constant	11.012***		
	(0.024)		
Origin-Sector-Skill-Year FE (α_t^{js})	Yes	Year FE (ζ_t)	Yes
Destination-Sector-Skill-Year FE (λ_t^{ki})	Yes	Origin-Skill FE (η_1^s)	Yes
Sector-to-Sector FE	Yes		
No. of Observations	50643	No. of Observations	603
R^2	0.830	R^2	0.424

Notes: Estimation results of equations (48) and (50). In Stage 1, the base category omitted is the non-employed-low-skill group, such that $\lambda_t^{ki} = 0$ for this category. In Stage 2, the time trend for the origin-low-skill group is omitted, as it is absorbed by the year FEs (ζ_t).

Table 8: Effects on the employment shares in Taiwan under different scenarios of tariff concessions

	(1) WTO accession by Taiwan	(2) WTO accession by China	(3) WTO accession by both	(4) Bilateral tariff concessions
		Panel A. Aggregate sector		
Primary Sector	−0.93%	0.22%	−0.62%	−0.49%
Manufacturing	6.06%	4.76%	5.65%	4.34%
Services	−1.37%	−1.81%	−1.39%	−0.68%
		Panel B. Individual sector		
Computer, Electronics	1.54%	0.56%	1.20%	0.28%
Basic & Fabricated Metals	0.87%	0.76%	0.85%	0.75%
Manufacturing n.e.c.	0.73%	0.72%	0.73%	0.74%
Textiles, Leather, Footwear	0.64%	0.52%	0.60%	0.47%
Food Beverage, Tobacco	0.42%	0.43%	0.42%	0.42%
Petroleum, Chemicals	0.41%	0.37%	0.40%	0.32%
Machinery, Equipment	0.40%	0.37%	0.40%	0.36%
Other Business Services	0.64%	0.63%	0.65%	0.68%
Financial Intermediation	0.38%	0.38%	0.38%	0.39%
Hotels, Restaurants	−0.20%	−0.23%	−0.25%	−0.02%
Construction	−0.29%	−0.46%	−0.33%	−0.42%
Wholesale, Retail	−1.95%	−1.86%	−1.86%	−1.35%
		Panel C. Skill type		
Low-skilled workers	−5.19%	−4.32%	−4.98%	−4.57%
Middle-skilled workers	2.02%	2.05%	2.05%	2.17%
High-skilled workers	3.17%	2.27%	2.93%	2.39%

Notes: The table reports the effect on the employment share in the Taiwanese labor market under different scenarios of tariff concessions over the period 1995–2020. The effect is calculated as the difference between the baseline economy and the counterfactual economy. Panel A shows the employment effect across broad sectors. Panel B shows the employment effect for individual sectors that contribute significantly to the aggregate differences across scenarios. Panel C shows the employment effect across skill types. Column (1) reports the employment effect of Taiwan's WTO accession. Column (2) reports the employment effect of China's WTO accession. Column (3) reports the combined employment effect of the WTO accession by both Taiwan and China. Column (4) reports the employment effect of bilateral tariff concessions between Taiwan and China.

Table 9: Effects on the capital growth rates in Taiwan under different scenarios of tariff concessions

	(1) WTO accession by Taiwan	(2) WTO accession by China	(3) WTO accession by both	(4) Bilateral tariff concessions
		Panel A. Aggregate sector		
Primary Sector	118.11 p.p.	208.26 p.p.	142.65 p.p.	152.93 p.p.
Manufacturing	244.11 p.p.	159.11 p.p.	219.39 p.p.	125.49 p.p.
Services	97.22 p.p.	95.72 p.p.	99.76 p.p.	114.67 p.p.
		Panel B. Individual sector		
Computer, Electronics	622.12 p.p.	266.10 p.p.	502.20 p.p.	168.76 p.p.
Machinery, Equipment	367.09 p.p.	326.26 p.p.	360.80 p.p.	304.70 p.p.
Basic & Fabricated Metals	297.45 p.p.	268.73 p.p.	292.43 p.p.	265.75 p.p.
Manufacturing n.e.c.	193.25 p.p.	187.06 p.p.	190.60 p.p.	196.35 p.p.
Petroleum, Chemicals	187.74 p.p.	137.31 p.p.	180.06 p.p.	90.02 p.p.
Hotels, Restaurants	242.14 p.p.	242.07 p.p.	239.26 p.p.	254.98 p.p.
Construction	220.73 p.p.	217.12 p.p.	220.01 p.p.	218.88 p.p.
Financial Intermediation	194.62 p.p.	199.04 p.p.	197.96 p.p.	207.26 p.p.
Other Business Services	165.13 p.p.	160.48 p.p.	166.46 p.p.	177.39 p.p.
Wholesale, Retail	16.05 p.p.	25.77 p.p.	29.79 p.p.	108.93 p.p.

Notes: The table reports the effect on the capital growth rate in the Taiwanese economy under different scenarios of tariff concessions over the period 1995–2020. The effect is calculated as the difference (in percentage points) between the baseline economy and the counterfactual economy. Panel A shows the effect across broad sectors. Panel B shows the effect for individual sectors that contribute significantly to the aggregate differences across scenarios. Column (1) reports the effect of Taiwan's WTO accession. Column (2) reports the effect of China's WTO accession. Column (3) reports the combined effect of WTO accession by both Taiwan and China. Column (4) reports the effect of bilateral tariff concessions between Taiwan and China.

Table 10: Welfare effects on Taiwanese workers under different scenarios of tariff concessions

Scenario	Aggregate workers	Low-skilled workers	Middle-skilled workers	High-skilled workers
WTO accession by Taiwan (benchmark)	3.148%	2.270%	2.753%	4.629%
WTO accession by China	2.799%	2.127%	2.327%	4.105%
WTO accession by both	3.052%	2.237%	2.641%	4.472%
Bilateral tariff concessions	2.830%	2.104%	2.389%	4.169%
Benchmark, but without skill upgrading	0.489%	-0.002%	0.341%	1.243%
Benchmark, but with constant capital	3.349%	2.713%	3.457%	4.019%
		Primary	Manufacturing	Services
WTO accession by Taiwan (benchmark)		2.592%	3.453%	3.084%
WTO accession by China		2.427%	3.172%	2.696%
WTO accession by both		2.595%	3.383%	2.971%
Bilateral tariff concessions		2.422%	3.215%	2.725%
Benchmark, but without skill upgrading		0.148%	0.249%	0.6%
Benchmark, but with constant capital		2.262%	3.565%	3.357%

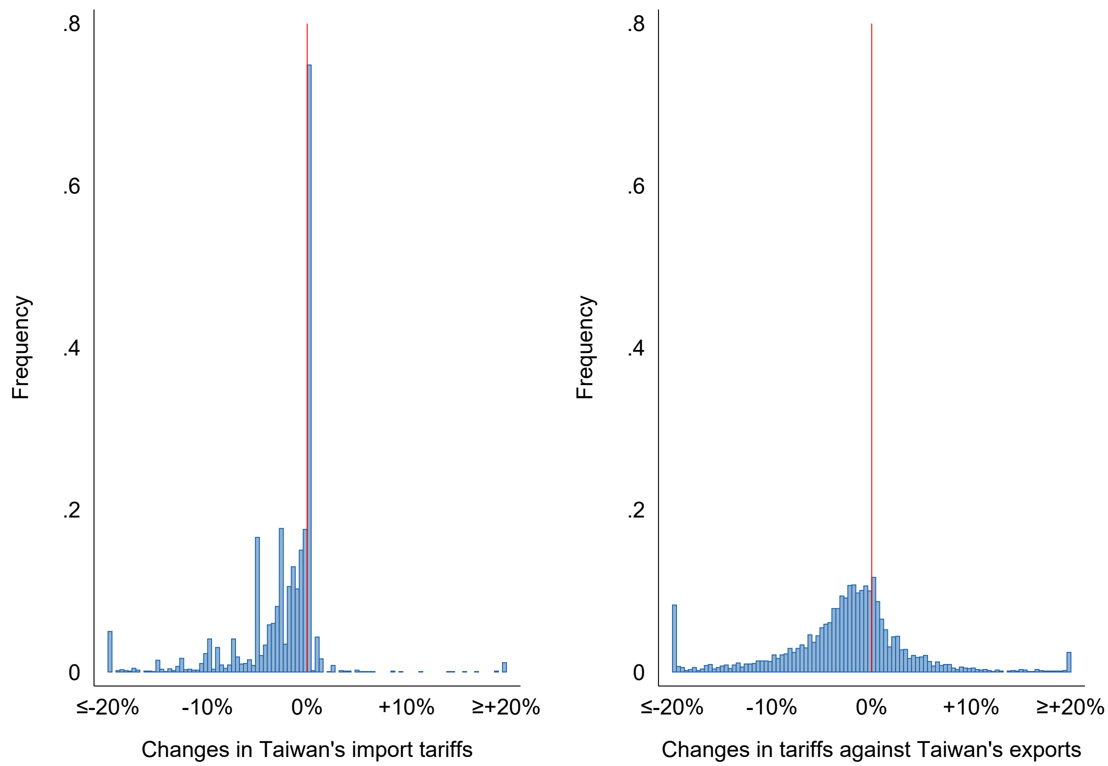
Notes: The table reports the welfare effect on Taiwanese workers under different scenarios of tariff concessions over the period 1995–2020. In addition, we report the results under the benchmark case (WTO Accession by Taiwan) but without skill upgrading, and under the benchmark case but with the capital stock and allocation across sectors kept fixed at the 1995 level. The welfare effect is measured in terms of total discounted consumption equivalent variation over the period. The labor market in Taiwan is sector-skill specific. The first column lists the scenarios studied. The second column reports the aggregate welfare effect across all sectors and skills, computed using sector-skill labor value-added shares in 1995 as weights. The third to fifth columns in the first panel report the welfare effects on low/middle/high-skilled workers, using sector-skill labor value-added shares (normalized by each skill type's labor value-added share) in 1995 as weights. The third to fifth columns in the second panel report the welfare effects on workers in the primary/manufacturing/service sectors, using sector-skill labor value-added shares (normalized by each sector's labor value-added share) in 1995 as weights. Refer to Table A.4 for the sector-skill value-added shares in 1995.

Table 11: Effects on aggregate/capital owner/worker welfare under different scenarios of tariff concessions

Scenario	Aggregate	Capital Owners	Workers
WTO accession by Taiwan (benchmark)	2.992%	2.697%	3.148%
WTO accession by China	2.495%	1.919%	2.799%
WTO accession by both	2.871%	2.528%	3.052%
Bilateral tariff concessions	2.552%	2.026%	2.830%
Benchmark, but without skill upgrading	0.646%	0.802%	0.489%
Benchmark, but with constant capital	2.884%	2.005%	3.349%

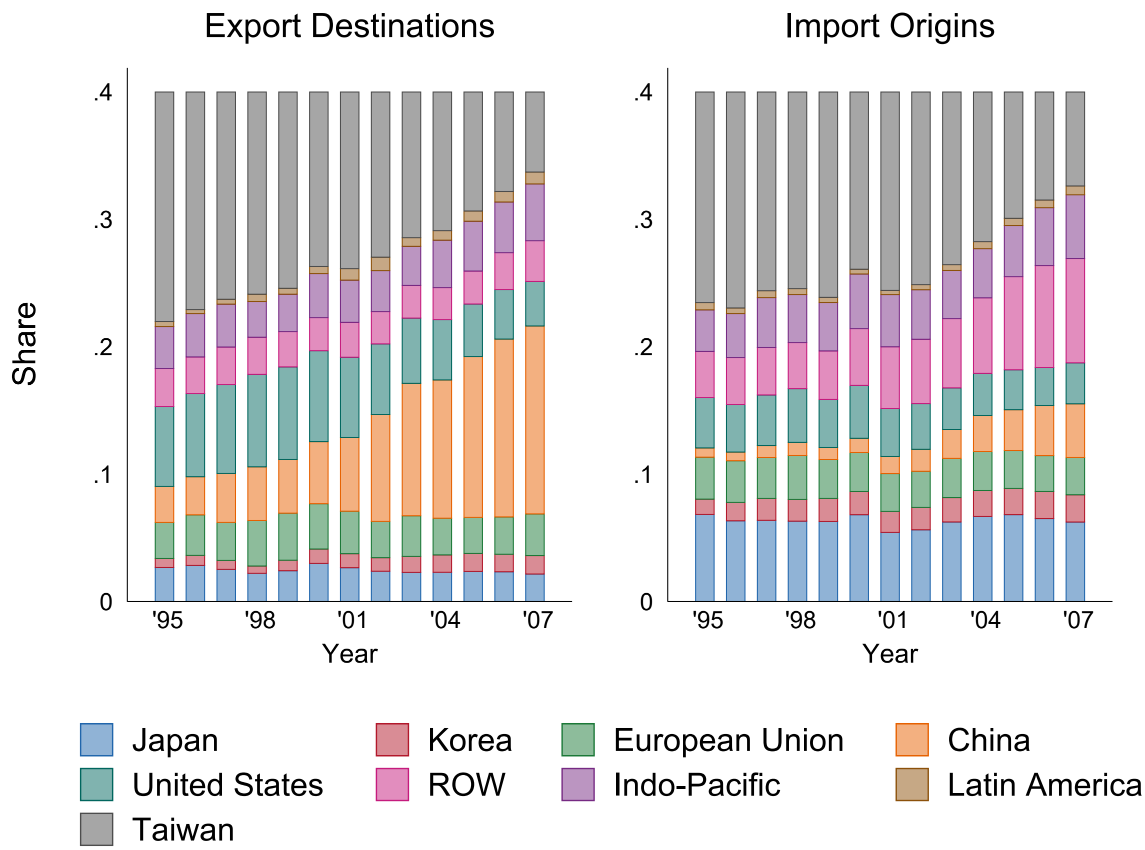
Notes: The table reports the effects on Taiwanese aggregate/capital owner/worker welfare under different scenarios of tariff concessions over the period 1995–2020. In addition, we report the results under the benchmark case (WTO Accession by Taiwan) but without skill upgrading, and under the benchmark case but with the capital stock and allocation across sectors kept fixed at the 1995 level. The welfare effect is measured in terms of total discounted consumption equivalent variation over the period. The first column lists the scenarios studied. The second column reports the effect on welfare aggregated across capital owners and workers of all sectors and skills, using value-added shares in 1995 as weights. The third column reports the welfare effect on capital owners. The fourth column reports the welfare effects on workers across sectors and skills, using labor value-added shares in 1995 as weights. Refer to Table A.4 for the sector-skill / sector-capital value-added shares in 1995.

Figure 1: Changes in tariff rates at HS 6-digit level, 1995–2007



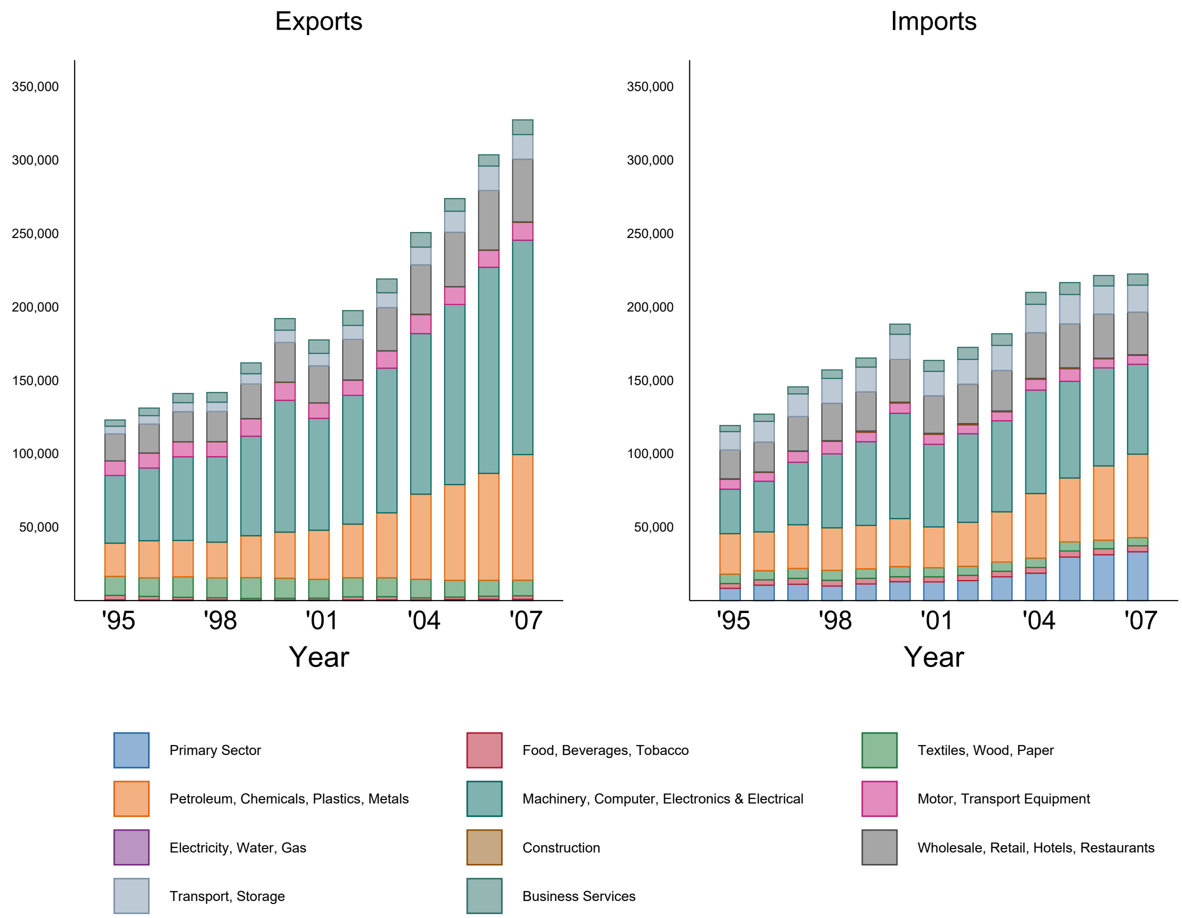
Notes: Each bar measures the frequency of the percentage point change in the tariff rates at HS 6-digit product code level from 1995 to 2007. Data were downloaded from WITS database. Trading partners include all economies available in the WITS database. The numbers reported are average change for each HS 6-digit product across all trading partners weighted by the WITS trade value. The left panel reports the percentage point change in Taiwan's import tariffs. The right panel reports the percentage point change in tariffs that Taiwan's trading partners imposed on Taiwanese exports.

Figure 2: Distribution of Taiwan's trade with its trading partners, 1995–2007



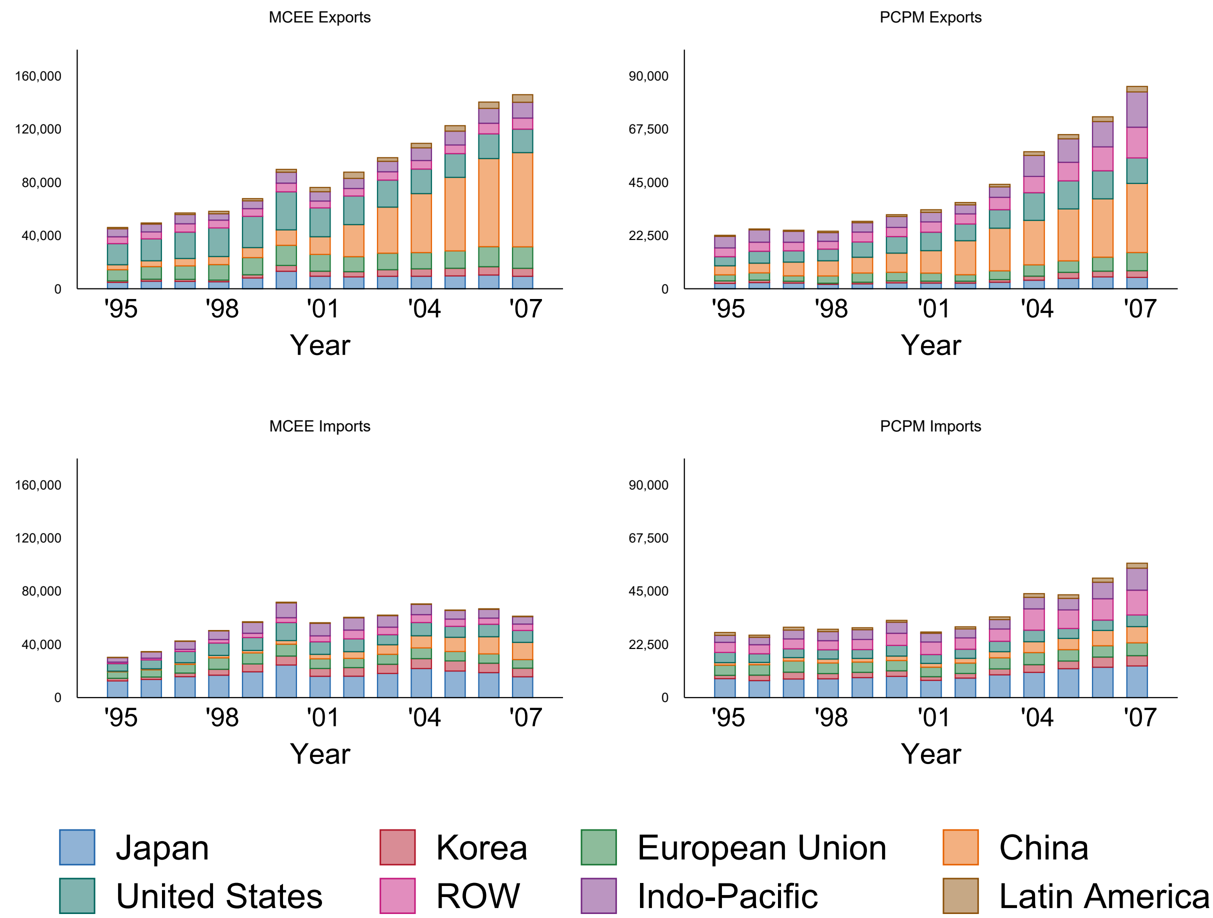
Notes: The length of each colored bar measures the share of Taiwan's trade with each of its trading partners in a year. The gray-colored bar with legend "Taiwan" measures the Taiwanese domestic trade share (truncated at 0.4). Trade data are from the OECD TiVA ICIO Tables (2016 edition). The left panel reports the shares of Taiwan's exports to each of its export destinations. The right panel reports the shares of Taiwan's imports from each of its import origins. Trading partners include all economy entities in TiVA. "ROW" here refers to the residual economies not covered by the other groups reported. European Union includes all TiVA economies that were members of the EU in 2007. ASEAN+3 includes (a) all TiVA economies that were members of the ASEAN in 2007; and (b) India, Australia, and New Zealand.

Figure 3: Taiwan's trade volume by sector, 1995–2007



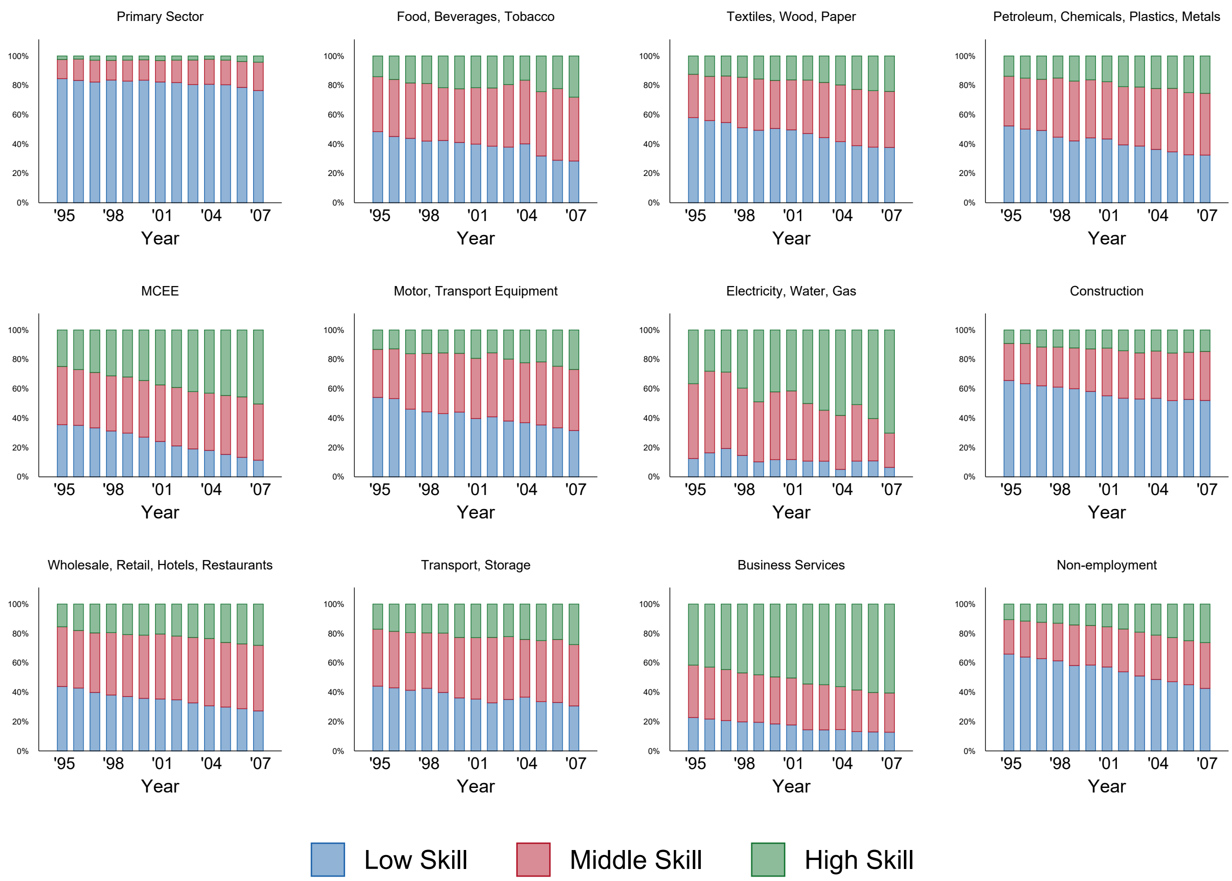
Notes: The length of each colored bar measures the total export/import value of Taiwan in each sector in a particular year. Trade data are from the OECD TiVA ICIO Tables (2016 edition). The left panel reports the value of Taiwan's exports in each sector. The right panel reports the value of Taiwan's imports in each sector. Sector definitions follow Table 2.

Figure 4: Taiwan's trade volume by sector and partner for selected sectors, 1995–2007



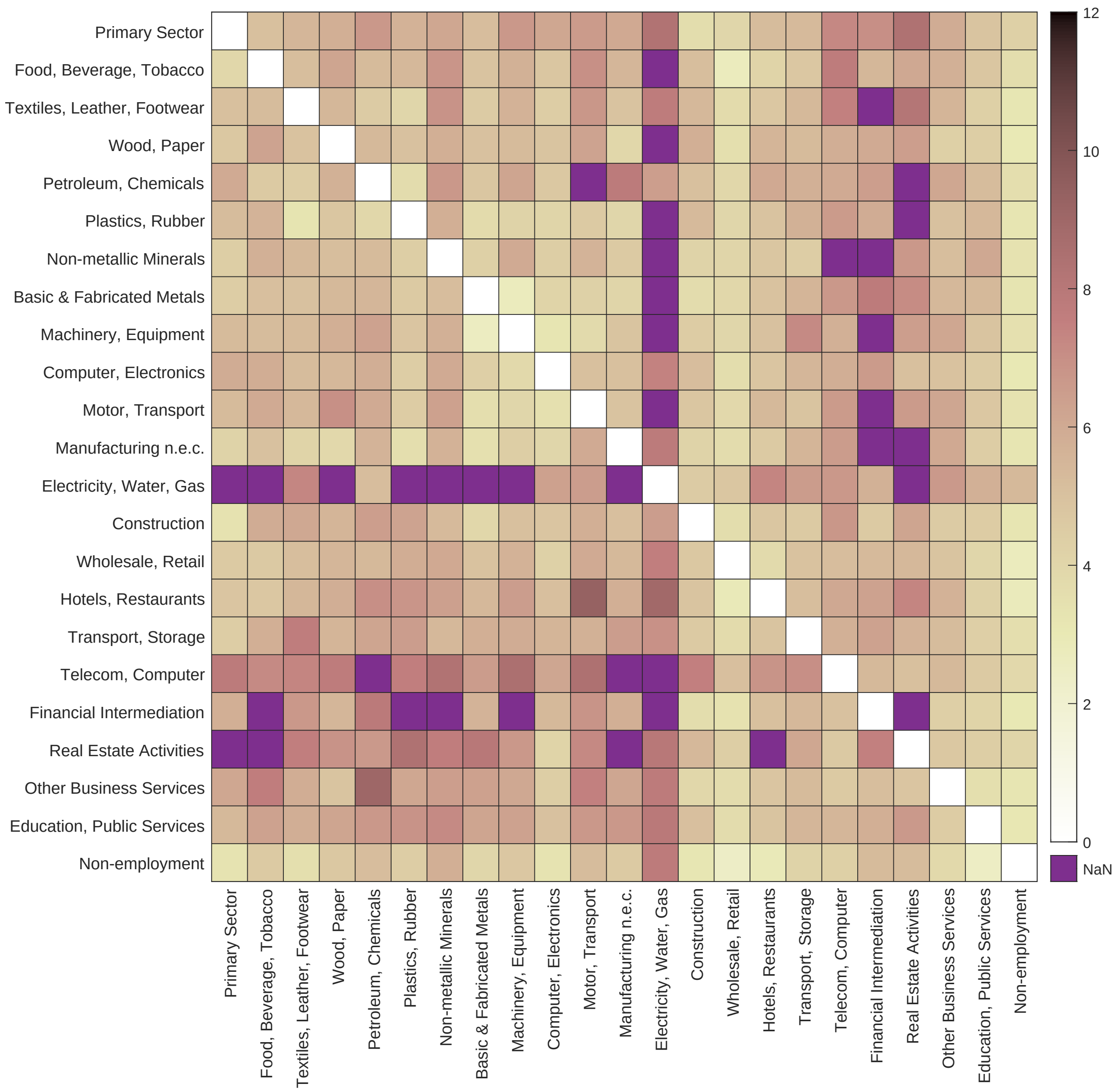
Notes: The length of each colored bar measures the corresponding export/import value of Taiwan with respect to each trade partner for the selected sectors. Trade data are from the OECD TiVA ICIO Tables (2016 edition). The upper panels report the value of Taiwan's exports to each of its export destinations for MCEE and PCPM (from left to right). The lower panels report the value of Taiwan's imports from each of its import origins for the same two sectors. Trading partners include all economy entities in TiVA. "ROW" here refers to the residual economies not covered by the other groups reported. European Union includes all TiVA economies that were members of the EU in 2007. ASEAN+3 includes (a) all TiVA economies that were members of the ASEAN in 2007; and (b) India, Australia, and New Zealand.

Figure 5: Evolution of skill shares across sectors in Taiwan, 1995–2007



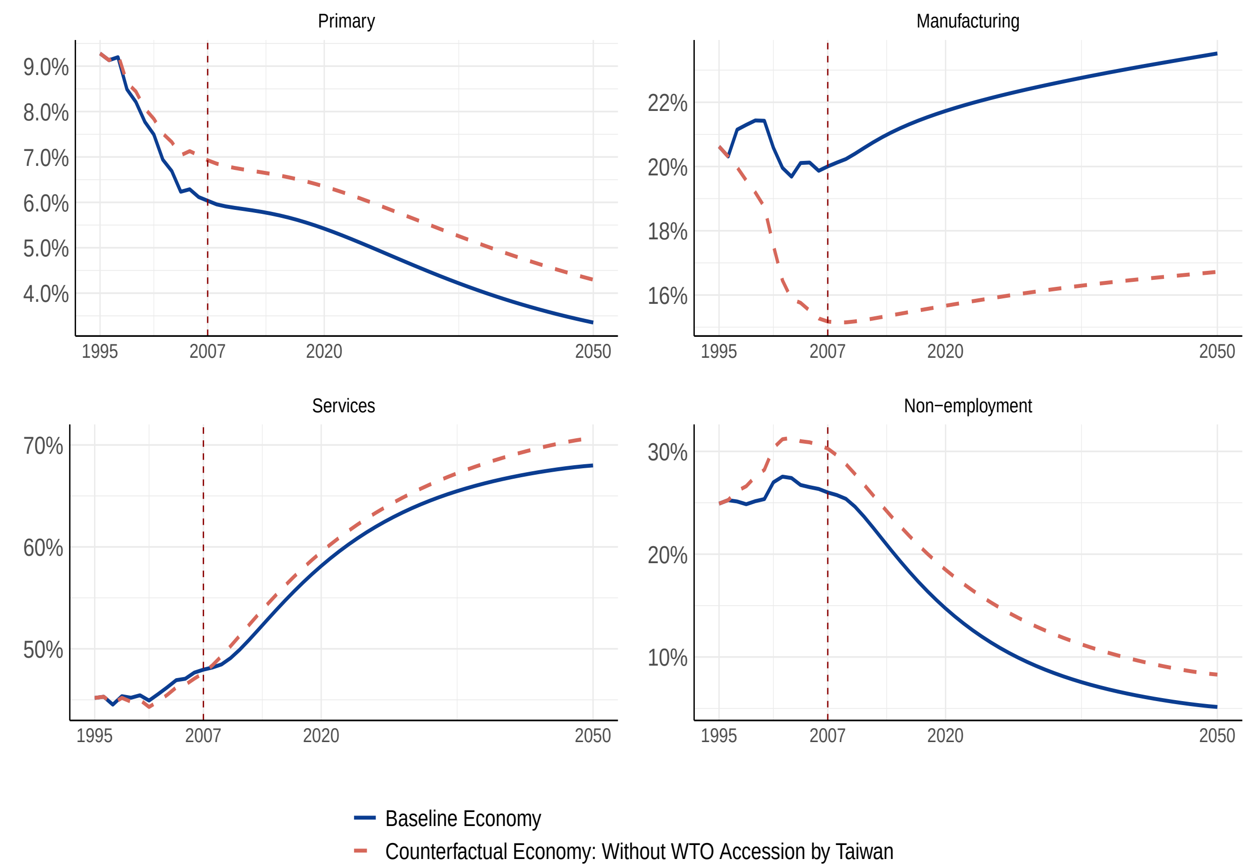
Notes: Statistics are computed based on the *Manpower Utilization Quasi-longitudinal Data* from 1995 to 2007. The numbers reported are the proportion of labor in a particular skill group in each year during 1995–2007. Sector definitions follow Table 5. The shares of high-, middle-, and low-skilled workers in the population changed from 17.4%, 30.3%, and 52.3% in 1995 to 34.7%, 34.5%, and 30.8% in 2007, respectively. The total population is measured as the sum of employed, unemployed, and not-in-labor-force, as elaborated in Appendix A.1. Non-employment equals the sum of unemployed and not-in-labor-force.

Figure 6: Sector-to-sector switching cost



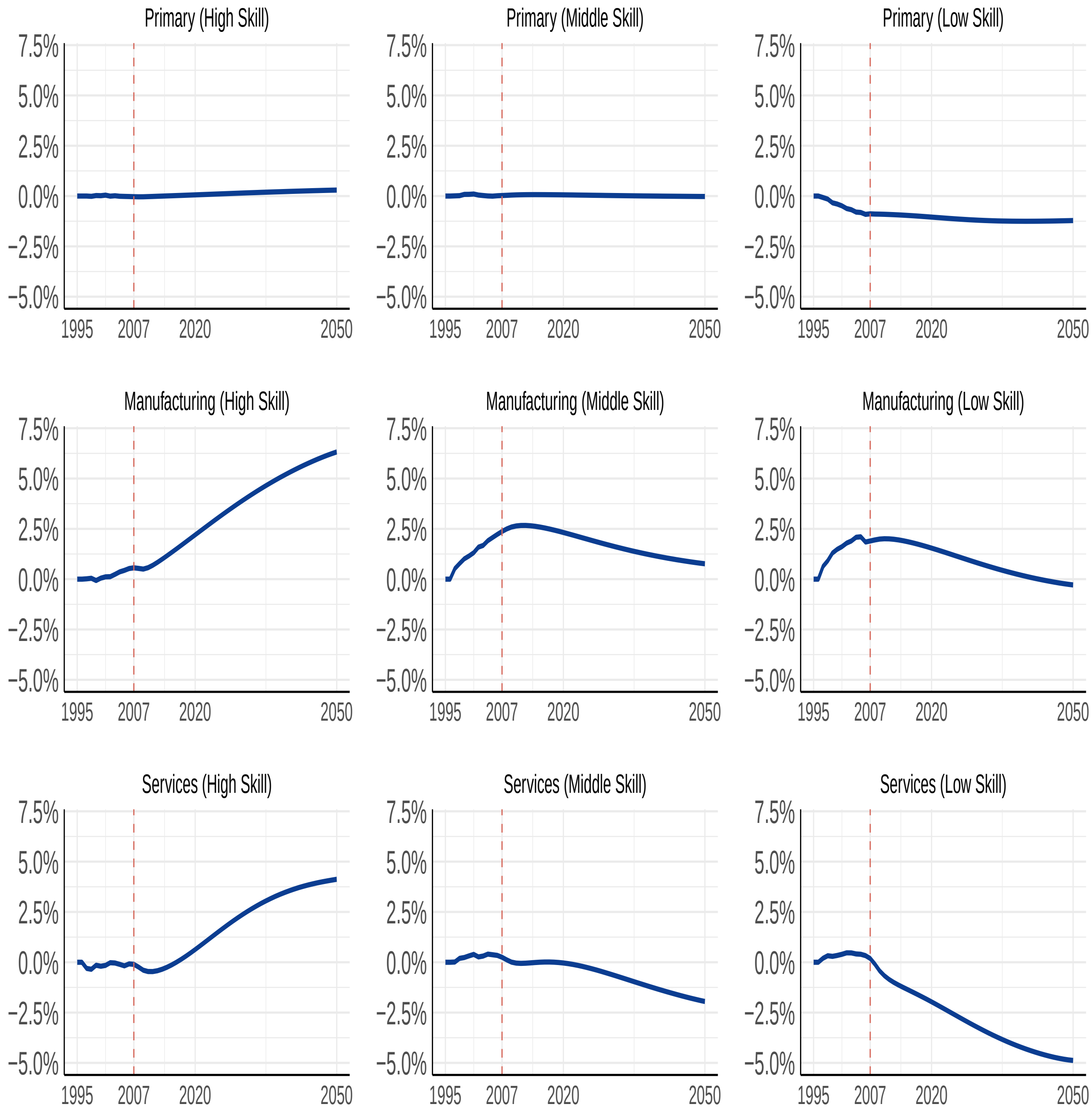
Notes: The figure shows the sector-to-sector switching costs based on estimations of Stage-1 equation (48) and the switching-cost specification in equation (49). The origin-sectors are in the rows and the destination-sectors in the columns. The magnitudes reported above reflect the average sector-switching costs with or without skill upgrading.

Figure 7: Transition dynamics of employment shares in Taiwan — effects of Taiwan's WTO entry



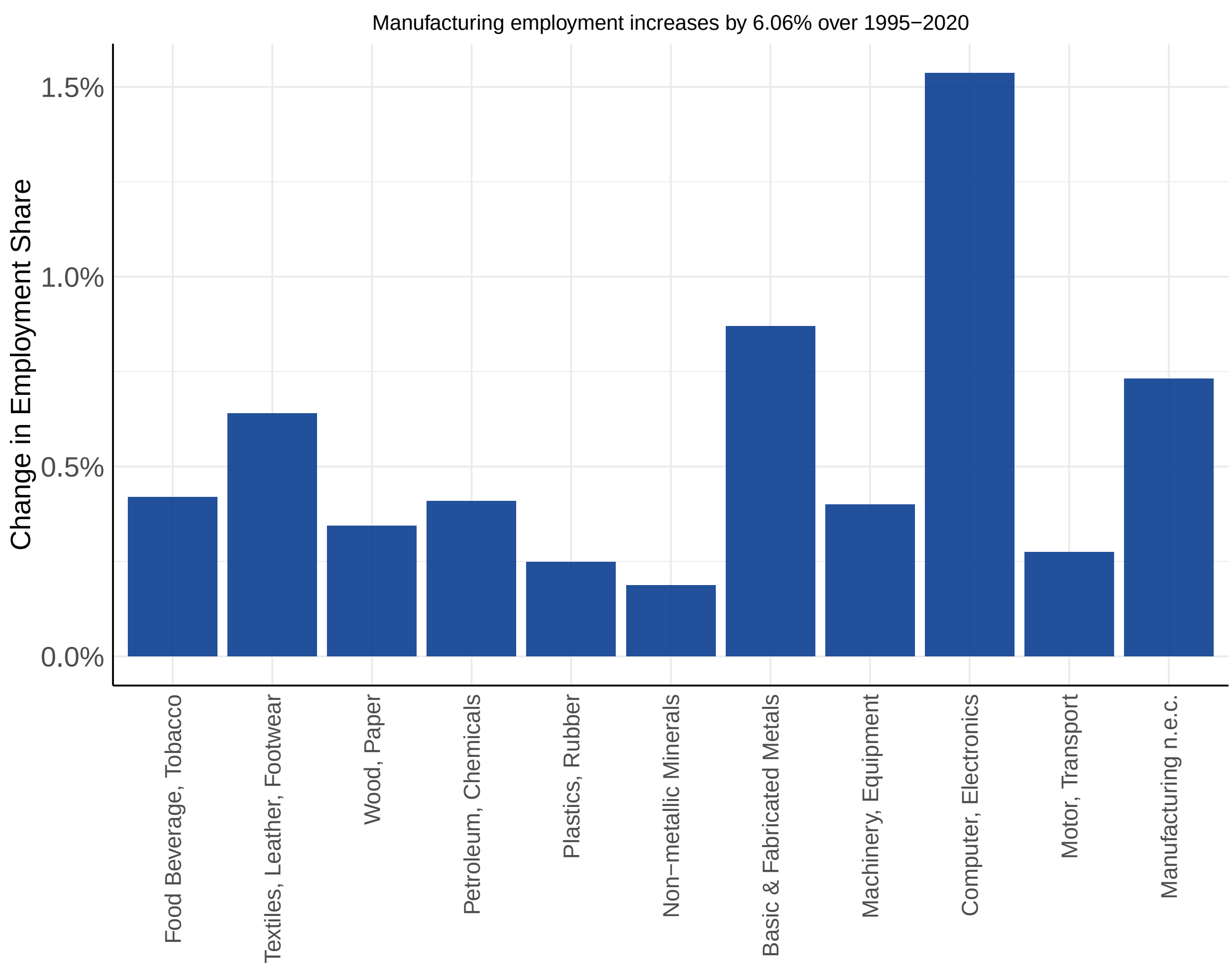
Notes: The figure shows the effect of Taiwan's WTO entry on employment shares in Taiwan by broad sectors. The change in employment shares is measured in terms of shares of total population (employed, unemployed, plus not-in-labor-force). The baseline economy shows the path of employment shares with all time-varying fundamentals evolving as in the data from 1995 to 2007 and constant fundamentals after 2007. In the counterfactual economy, Taiwan's tariffs on imports and foreign tariffs on Taiwan's exports are set to their levels in 1995. We simulate the model until 2050.

Figure 8: Transition dynamics of employment shares in Taiwan by skill groups — effects of Taiwan's WTO entry



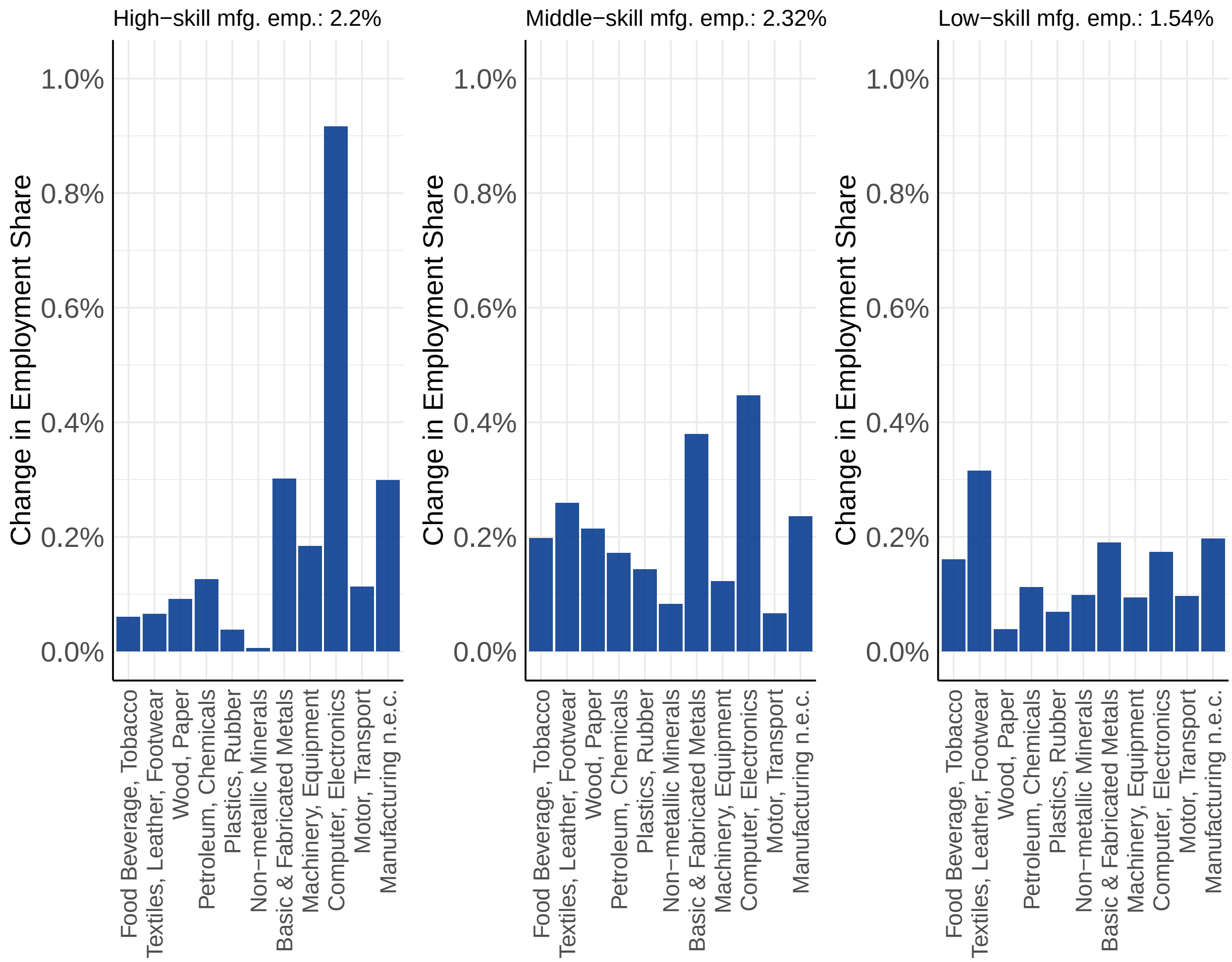
Notes: The figure shows the effect of Taiwan's WTO entry on employment shares in Taiwan by broad sectors and skill groups. The change in employment shares is measured in terms of shares of total population (employed, unemployed, plus not-in-labor-force). The effect is calculated to be the difference between the baseline economy and the counterfactual economy. The baseline economy shows the path of employment shares with all time-varying fundamentals evolving as in the data from 1995 to 2007 and constant fundamentals after 2007. In the counterfactual economy, Taiwan's tariffs on imports and foreign tariffs on Taiwan's exports are set to their levels in 1995. We simulate the model until 2050.

Figure 9: Effects of Taiwan's WTO entry on the employment shares of manufacturing sectors in Taiwan



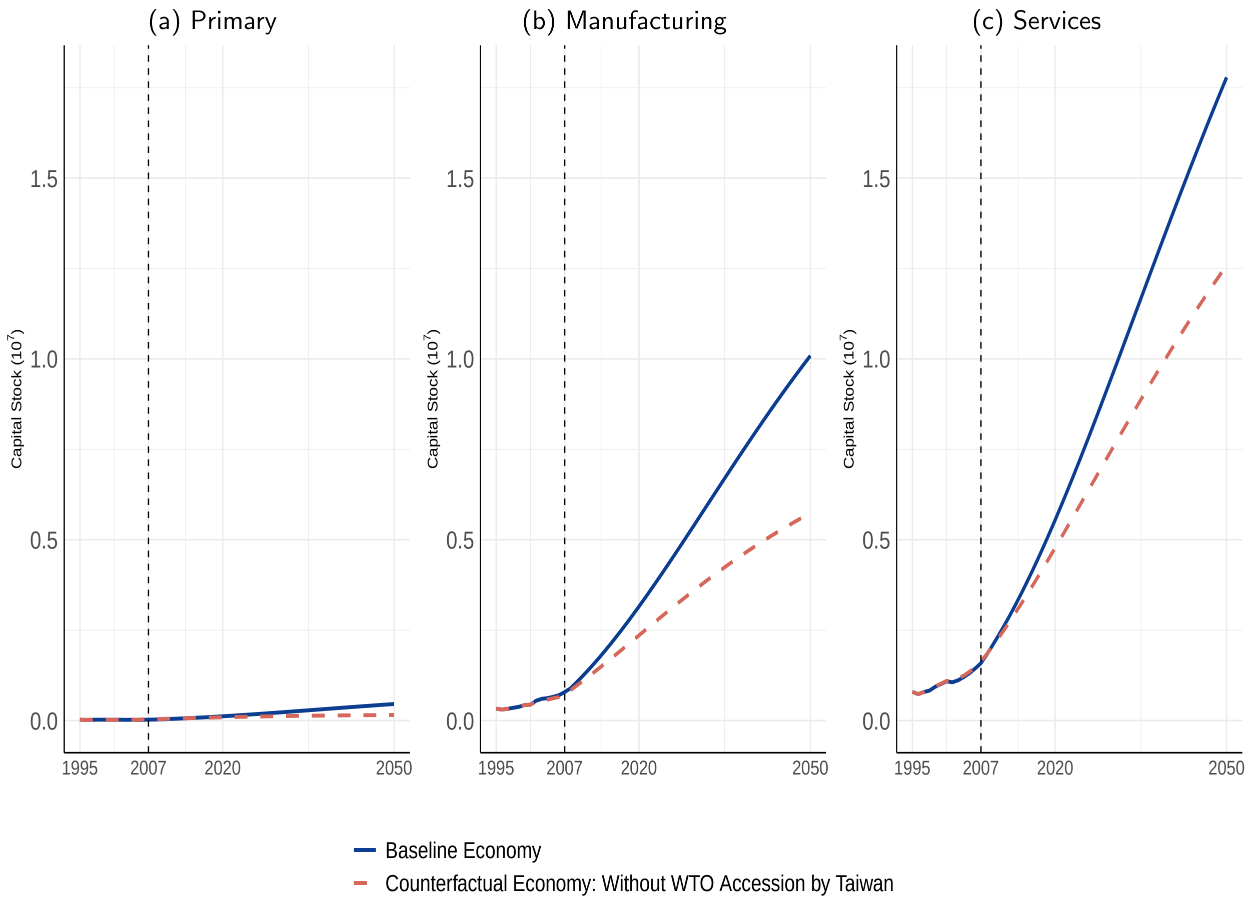
Notes: The figure shows the change in employment share for each manufacturing sector in Taiwan over the period of 1995–2020, due to Taiwan's WTO entry. The change in employment shares is measured in terms of shares of total population (employed, unemployed, plus not-in-labor-force). The effect is calculated to be the difference between the baseline economy and the counterfactual economy. See Figure 7 footnote for the definitions of the baseline and the counterfactual economy.

Figure 10: Effects of Taiwan's WTO entry on the employment shares of manufacturing sectors in Taiwan by skill groups



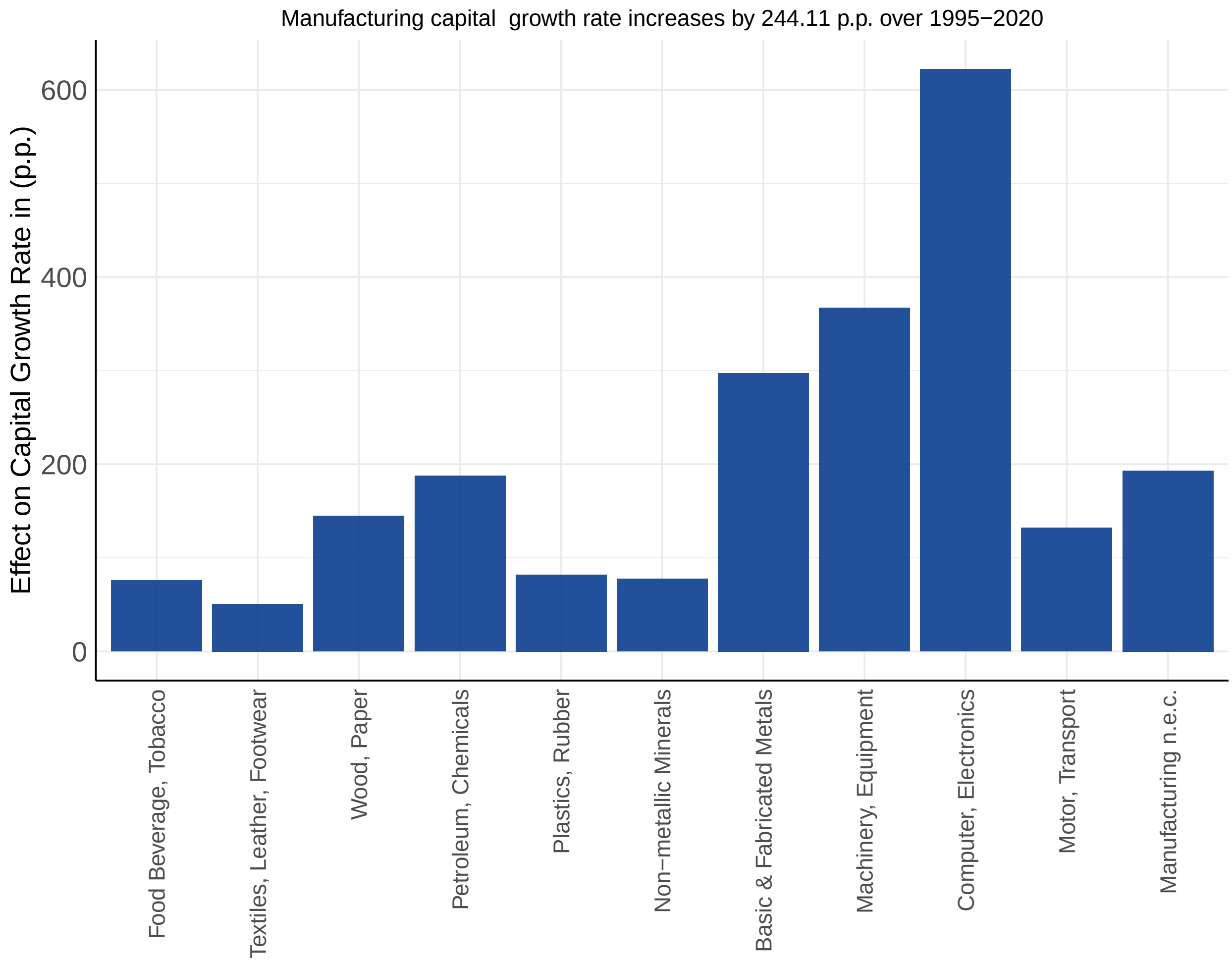
Notes: The figure shows the change in employment share by skill groups for each manufacturing sector in Taiwan over the period of 1995–2020, due to Taiwan's WTO entry. The change in employment shares is measured in terms of shares of total population (employed, unemployed, plus not-in-labor-force). The effect is calculated to be the difference between the baseline economy and the counterfactual economy. See Figure 7 footnote for the definitions of the baseline and the counterfactual economy.

Figure 11: Dynamics of capital stocks in Taiwan — effects of Taiwan's WTO entry



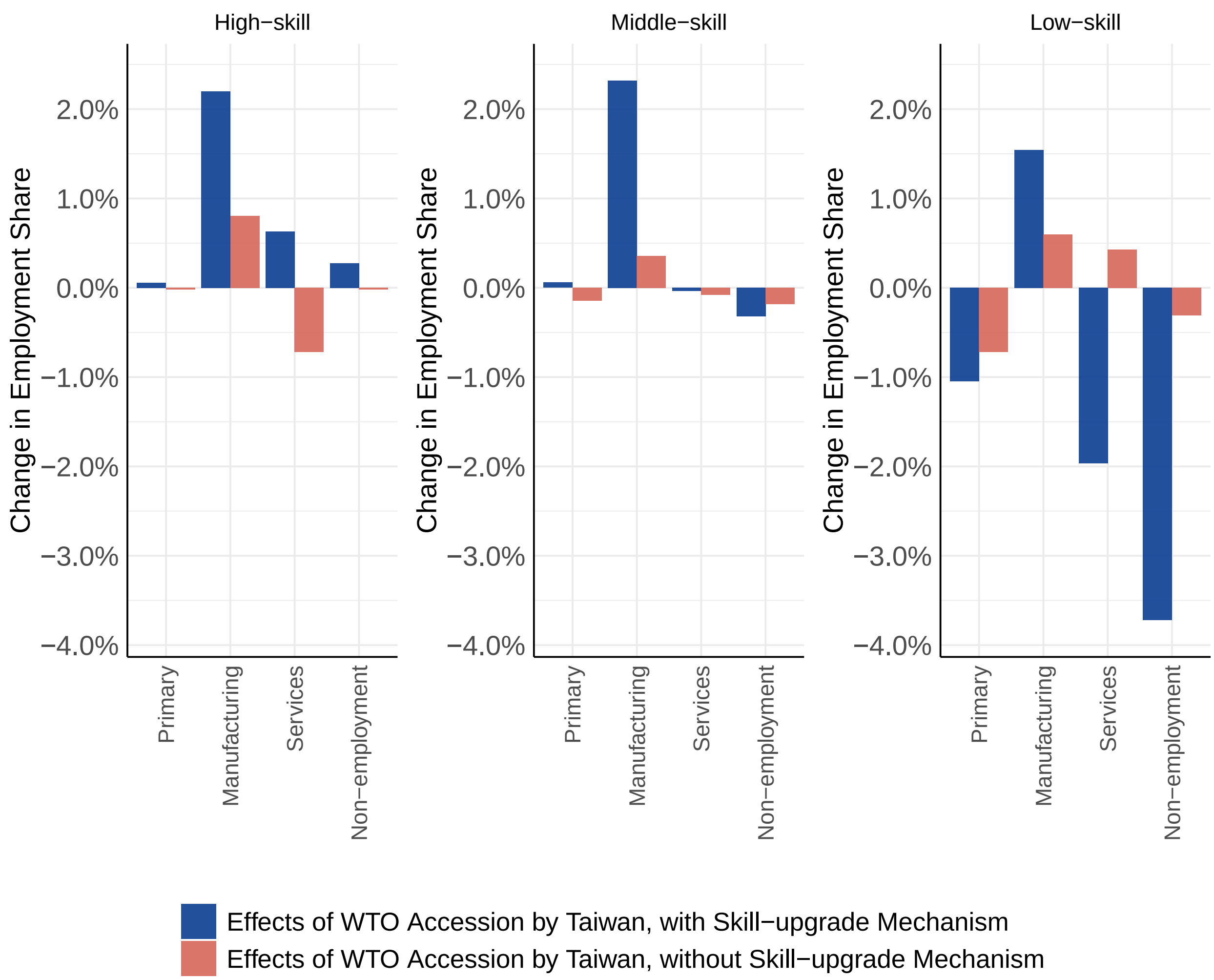
Notes: The figure shows the effect of Taiwan's WTO entry on capital stocks in Taiwan by broad sectors. The effect is illustrated by the difference between the baseline economy and the counterfactual economy. The baseline economy shows the path of capital stocks with all time-varying fundamentals evolving as in the data from 1995 to 2007 and constant fundamentals after 2007. The counterfactual economy is the same except that Taiwan's tariffs on imports and foreign tariffs on Taiwan's exports are set to their levels in 1995. We simulate the model until 2050.

Figure 12: Effects of Taiwan's WTO entry on the capital growth rate of manufacturing sectors in Taiwan



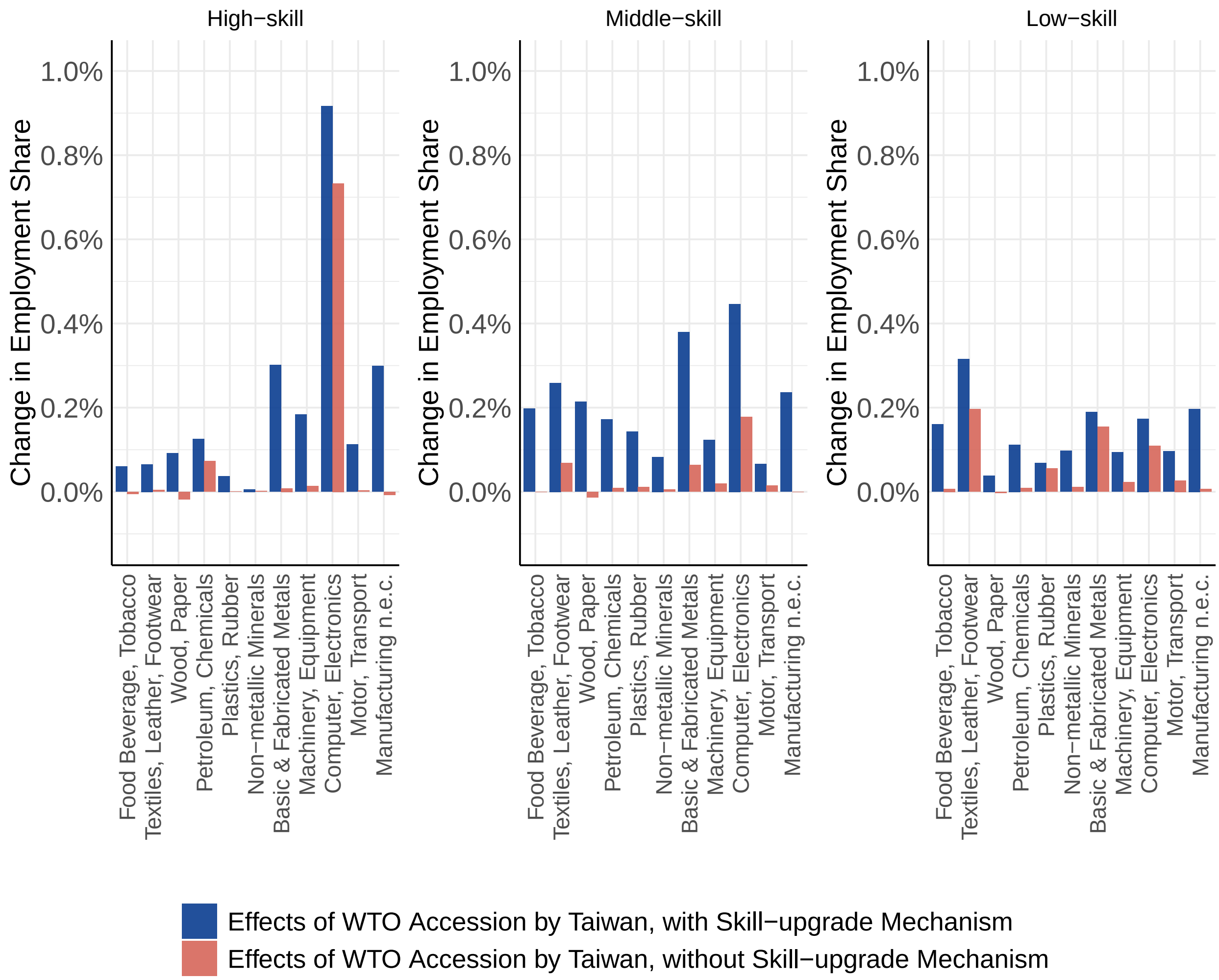
Notes: The figure shows the effect on the capital growth rate for each manufacturing sector in Taiwan over the period of 1995–2020, due to Taiwan's WTO entry. The effect is measured by the difference in growth rates (in percentage points) between the baseline economy and the counterfactual economy. See Figure 7 footnote for the definitions of the baseline and the counterfactual economy.

Figure 13: Effects of Taiwan's WTO entry on the employment shares in Taiwan by broad sectors and skill groups — The role of skill-upgrade mechanism



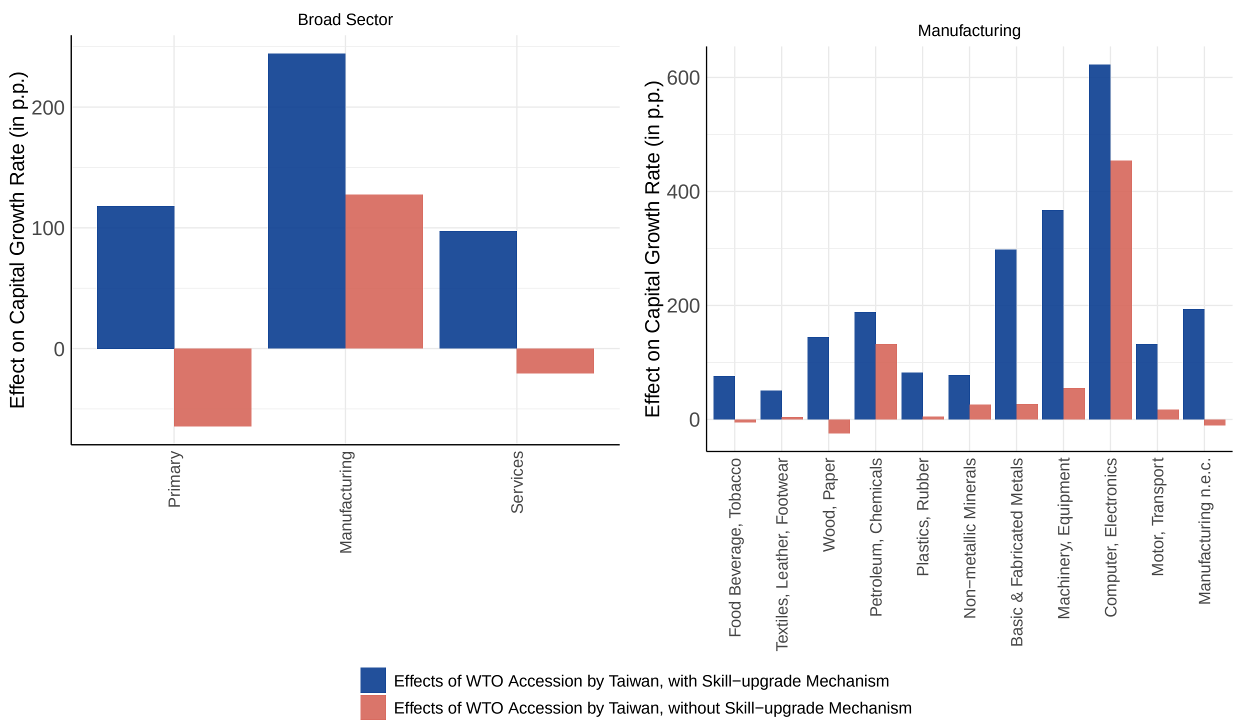
Note: The figure shows the effect of Taiwan's WTO entry on employment shares in Taiwan by broad sectors and skill groups over the period of 1995–2020. The change in employment shares is measured in terms of shares of total population (employed, unemployed, plus not-in-labor-force). In the scenario "Effects of WTO Accession by Taiwan (with Skill-upgrade Mechanism)," the effect is calculated to be the difference between the baseline economy (with WTO accession) and the counterfactual economy (without WTO accession), allowing for the skill-upgrade mechanism as modeled in the paper. See Figure 7 for the definitions of the baseline and the counterfactual economy. In the second scenario "Effects of WTO Accession by Taiwan (without Skill-upgrade Mechanism)," the effect is calculated as the difference between the baseline economy (with WTO accession) and the counterfactual economy (without WTO accession), in a setup without the skill-upgrade mechanism. In particular, the baseline economy is an economy where all time-varying fundamentals evolve as in the data from 1995 to 2007 (and remain constant after 2007), but the sector-skill transition costs if involving skill upgrade are set to be prohibitively high in 1996 onwards relative to the level in 1995, which effectively shuts down the skill-upgrade mechanism. The counterfactual economy is the same as the baseline economy without skill-upgrade mechanism, except that Taiwan's tariffs on imports and foreign tariffs on Taiwan's exports are set to their levels in 1995. We simulate the model until 2050.

Figure 14: Effects of Taiwan's WTO entry on the employment shares in Taiwan by manufacturing sectors and skill groups — The role of skill-upgrade mechanism



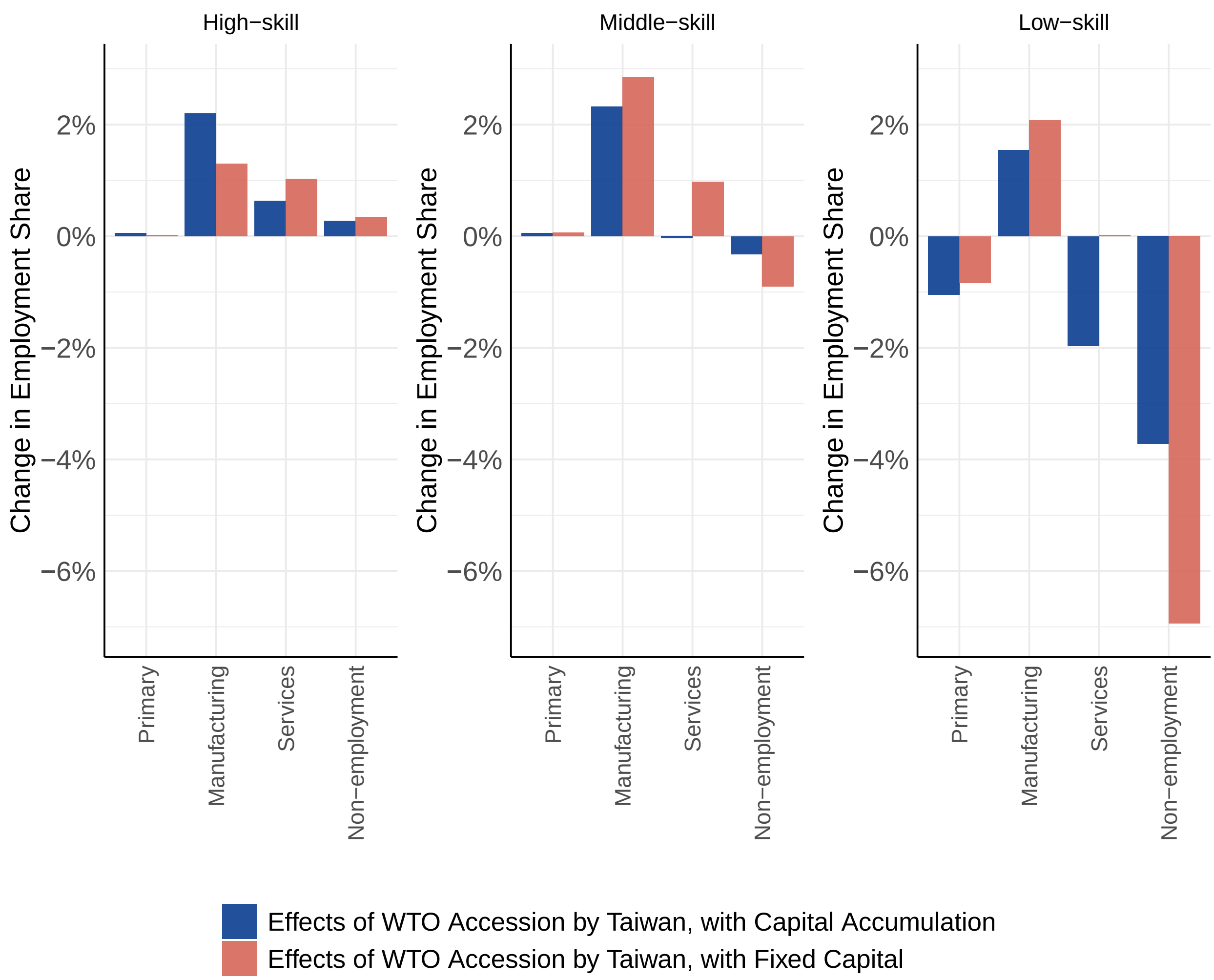
Note: The figure shows the effect of Taiwan's WTO entry on employment shares in Taiwan by manufacturing sectors and skill groups over the period of 1995–2020. See Figure 13 for the setup of the two scenarios, "Effects of WTO Accession by Taiwan (with Skill-upgrade Mechanism)" and "Effects of WTO Accession by Taiwan (without Skill-upgrade Mechanism)."

Figure 15: Effects of Taiwan's WTO entry on the capital growth rates in Taiwan by broad sectors and by manufacturing sectors — The role of skill-upgrade mechanism



Note: The figure shows the effect of Taiwan's WTO entry on the capital growth rates in Taiwan by broad sectors over the period of 1995–2020, and by manufacturing sectors. The effect is measured by the difference in growth rates (in percentage points) between the baseline economy and the counterfactual economy, under the scenario with the skill-upgrade mechanism and the scenario without the skill-upgrade mechanism. See Figure 13 for the setup of the two scenarios, "Effects of WTO Accession by Taiwan (with Skill-upgrade Mechanism)" and "Effects of WTO Accession by Taiwan (without Skill-upgrade Mechanism)."

Figure 16: Effects of Taiwan's WTO entry on the employment shares in Taiwan by broad sectors and skill groups — The role of capital accumulation



Note: The figure shows the effect of Taiwan's WTO entry on employment shares in Taiwan by broad sectors and skill groups over the period of 1995–2020. The change in employment shares is measured in terms of shares of total population (employed, unemployed, plus not-in-labor-force). In the scenario "Effects of WTO Accession by Taiwan (with Capital Accumulation)," the effect is calculated to be the difference between the baseline economy (with WTO accession) and the counterfactual economy (without WTO accession), allowing for capital accumulation as modeled in the paper. See Figure 7 for the definitions of the baseline and the counterfactual economy. In the second scenario "Effects of WTO Accession by Taiwan (with Fixed Capital)," the effect is calculated as the difference between the baseline economy (with WTO accession) and the counterfactual economy (without WTO accession), in a setup where capital stock and its allocation across sectors are held fixed at the 1995 level. We simulate the model until 2050.

Table A.1: Sector concordance between ISIC Rev 3 and Taiwanese SIC

ISIC Rev 3	ISIC Rev 3 Descriptions	ROC SIC 5 (1995–1996)	ROC SIC 6 (1997–2001)	ROC SIC 7 (2002–2006)	ROC SIC 8 (2007)
c01t05	Agriculture, hunting, forestry and fishing	01–03	01–03	01–03	01–03
c10t14	Mining and quarrying	05–09	05–09	04–06	05–07
c15t16	Food products, beverages and tobacco	11–12	11–12	08–09	08–10
c17t19	Textiles, textile products, leather and footwear	13–15	13–15	10–12	11–13
c20	Wood and products of wood and cork	16	16	13	14
c21t22	Pulp, paper, paper products, printing and publishing	18–19, 83	18–19, 83	15–16, 84	15– 16, 58
c23	Coke, refined petroleum products and nuclear fuel	23	23	19	17
c24	Chemicals and chemical products	21–22	21–22	17–18	18–20
c25	Rubber and plastics products	24–25	24–25	20–21	21–22
c26	Other non-metallic mineral products	26	26	22	23
c27t28	Basic metals and fabricated metal products	27–28	27–28	23–24	24–25
c29	Machinery and equipment, nec	29	29	25	29, 34
c30t33	Computing, electrical and optical equipment	31, 33	31, 33	26–28, 30	26–28
c34t35	Transport equipment	32	32	29	30–31
c36t37	Manufacturing nec; recycling	17, 39	17, 39	14, 31	32–33
c40t41	Electricity, gas and water supply	41–44	41–44	33–36	35–36
c45	Construction	45–49	45–49	38–42	41–43, 81
c50t52	Wholesale and retail trade; repairs	51–57	51–56	44–48, 95	45–48
c55	Hotels and restaurants	58, 88	57, 88	50–51	55–56
c60t63	Transport and storage	61–62	61–62	53–58	49–53, 79
c64 and c72	Post and telecommunications; Computer and related activities	63, 75	63, 75	59–60, 72– 73	54, 61–63
c65t67	Financial intermediation	65–67	65–67	62–64	64–66
c70	Real estate activities	68	68	66	67–68
c71	Renting of machinery and equipment	78	78	67	77
c73t74	R&D and other business activities	71–74, 76, 77, 79	71–74, 76, 77, 79	69–71, 74–77, 92	69–76, 78, 80, 82
c75t95	Community, social and personal services	Else	Else	Else	Else

Notes: In the quantitative simulation analysis, we combine: c01t05 and c10t14; c20 and c21t22; c23 and c24; and c71 and c73t74. In presenting the stylized facts, we group sectors further to reduce the dimensionality. The 12 aggregate sectors in the stylized facts are as follows: "Primary" includes c01t05 and c10t14. "Food, Beverages, Tobacco" includes c15t16. "Textiles, Wood, Paper" includes c17t19, c20 and c21t22. "Petroleum, Chemicals, Plastics, Metals" includes c23, c24, c25, c26, and c27t28. "Machinery, Computer, Electronics & Electrical" includes c29 and c30t33. "Motor, Transport Equipment" includes c34t35 and c36t37. "Electricity, Water, Gas" includes c40t41. "Construction" includes c45. "Wholesale, Retail, Hotels, Restaurants" includes c50t52 and c55. "Transport, Storage" includes c60t63. "Business Services" includes c64, c65t67, c70, c71, c72, c73t74, and c75t95. "Non-employment" includes unemployment and not-in-labor-force. See Appendix A.1 for the definition of not-in-labor-force observations.

Table A.2: Summary statistics for key parameters/variables

	Measurement	Source	Mean
			World/Taiwan/China
	Share of low-skilled labor compensation in labor value added in 1995	WIOD 2013	0.203/0.377/0.616
	Share of middle-skilled labor compensation in labor value added in 1995	WIOD 2013	0.499/0.315/0.345
	Share of high-skilled labor compensation in labor value added in 1995	WIOD 2013	0.299/0.308/0.039
	Share of capital in value added in 1995	WIOD 2013	0.390/0.346/0.455
γ^{nj}	Share of value added in gross output in 1995	TiVA 2016	0.524/0.446/0.391
$\gamma^{L,nj1}$	Share of low-skilled labor compensation in gross output in 1995	WIOD 2013 and TiVA 2016	0.065/0.110/0.131
$\gamma^{L,nj2}$	Share of middle-skilled labor compensation in gross output in 1995	WIOD 2013 and TiVA 2016	0.159/0.092/0.074
$\gamma^{L,nj3}$	Share of high-skilled labor compensation in gross output in 1995	WIOD 2013 and TiVA 2016	0.095/0.090/0.008
$\gamma^{K,nj}$	Share of capital in gross output in 1995	WIOD 2013 and TiVA 2016	0.204/0.154/0.178
			Primary/Manufacture/Services
α^{nj}	Final demand expenditure share in 1995	TiVA 2016	0.055/0.286/0.659
θ^{j}	Dispersion of productivity	CP 2015	8.59/4.58/10
			USA-TWN/USA-CHN/TWN-CHN/CHN-TWN
$\pi_{1995}^{nj,oj}$	Trade Share in 1995	TiVA 2016	1.7%/1.6%/1.7%/1.5%
$\pi_{2007}^{nj,oj}$	Trade Share in 2007	TiVA 2016	0.9%/10.1%/6.7%/4.3%
$\tau_{1995}^{nj,oj}$	Import Tariff in 1995	WITS	4.1%/6.5%/4.6%/20.4%
$\tau_{2007}^{nj,oj}$	Import Tariff in 2007	WITS	1.6%/2.8%/1.9%/4.6%

Notes: Measurements of the parameters/variables and sources of the data are documented in Appendix A. (i) The share of low-/middle-/high-skilled labor compensation in labor value added is available at the economy-sector level. The mean statistic for Taiwan/China reported in the table is computed using labor value added of each sector as weights. The mean statistic for "World" is computed using labor value added of each economy and sector as weights. (ii) The share of capital in value added is available at the economy-sector level. The mean statistic for Taiwan/China reported in the table is computed using value added of each sector as weights. The mean statistic for "World" is computed using value added of each economy and sector as weights. (iii) The share of value added in gross output used in the analysis is that for each economy-sector in 1995. (iv) The initial share of labor compensation in gross output by skill type used in the analysis is that for each economy-sector-skill in 1995. (v) The initial share of capital in gross output used in the analysis is that for each economy-sector in 1995. For (iii)–(v), the mean statistic for Taiwan/China reported in the table is computed using gross output of each sector as weights. The mean statistic for "World" is computed using gross output of each economy and sector as weights. In (i)–(v), the "World" refers to the set of 60 individual economies (excluding ROW). (vi) The final demand expenditure share used in the analysis is that for each economy-sector in 1995. The shares for primary/manufacture/services reported in the table are constructed by first summing the shares across individual sectors under each broad category within economy before taking the average across 60 individual economies. (vii) The mean productivity dispersion parameter for manufacture reported in the table is the unweighted average across the 11 manufacturing sectors used in the analysis. (viii) The trade share $\pi^{nj,oj}$ measures economy n's share of expenditures in sector j that is allocated to source o. The mean trade share for an economy-pair reported in the table is the average across sectors weighted by sectoral expenditures. (ix) The import tariff $\tau^{nj,oj}$ indicates the tariff rate imposed by economy n against source o in sector j. The mean tariff rate for an economy-pair reported in the table is the average across sectors weighted by sectoral import values. The economy-pair label (e.g., USA-TWN) indicates the importing-exporting economies. CP 2015: Caliendo and Parro (2015).

Table A.3: Employment shares of the Taiwanese labor market by sector and skill type in 1995

Sector	Low-skilled workers	Middle-skilled workers	High-skilled workers	Sector total
Primary Sector	7.81%	1.24%	0.23%	9.28%
Food Beverage, Tobacco	0.52%	0.42%	0.16%	1.10%
Textiles, Leather, Footwear	2.35%	0.86%	0.28%	3.50%
Wood, Paper	0.78%	0.70%	0.39%	1.87%
Petroleum, Chemicals	0.20%	0.41%	0.38%	1.00%
Plastics, Rubber	0.84%	0.53%	0.20%	1.57%
Non-metallic Minerals	0.40%	0.23%	0.10%	0.73%
Basic & Fabricated Metals	2.03%	1.10%	0.27%	3.40%
Machinery, Equipment	0.43%	0.43%	0.22%	1.08%
Computer, Electronics	1.45%	1.65%	1.11%	4.20%
Motor, Transport	0.40%	0.36%	0.17%	0.93%
Manufacturing n.e.c.	0.76%	0.36%	0.12%	1.24%
Electricity, Water, Gas	0.04%	0.18%	0.13%	0.35%
Construction	5.45%	2.07%	0.78%	8.30%
Wholesale, Retail	4.64%	5.21%	2.27%	12.13%
Hotels, Restaurants	2.01%	1.08%	0.16%	3.25%
Transport, Storage	1.39%	1.26%	0.57%	3.22%
Telecom, Computer	0.15%	0.90%	1.08%	2.13%
Financial Intermediation	0.07%	0.18%	0.14%	0.40%
Real Estate Activities	0.07%	0.29%	0.41%	0.77%
Other Business Services	0.22%	0.74%	0.58%	1.55%
Education, Public Services	3.48%	4.28%	5.33%	13.09%
Total: Manufacturing	10.18%	7.06%	3.38%	20.62%
Total: Services	17.53%	16.19%	11.46%	45.18%
Total: MCEE	1.88%	2.08%	1.32%	5.29%
Total: Business Services	4.00%	6.40%	7.54%	17.94%
Total: Exclud. non-employ.	35.53%	24.49%	15.07%	75.08%
Non-employment	16.50%	5.88%	2.53%	24.92%
Total	52.03%	30.37%	17.60%	100.00%

Notes: The table reports the employment shares of the Taiwanese labor market across sectors and skill types in 1995.

Table A.4: Value-added shares by sectors and factors of production for the Taiwanese economy in 1995

Sector	Low-skilled workers	Middle-skilled workers	High-skilled workers	Capital	Sector total
Primary Sector	2.80%	0.54%	0.20%	0.70%	4.25%
Food Beverage, Tobacco	0.49%	0.41%	0.26%	1.13%	2.29%
Textiles, Leather, Footwear	0.73%	0.56%	0.35%	0.49%	2.13%
Wood, Paper	0.53%	0.23%	0.13%	0.22%	1.10%
Petroleum, Chemicals	0.84%	0.36%	0.21%	3.20%	4.61%
Plastics, Rubber	0.76%	0.33%	0.19%	0.35%	1.64%
Non-metallic Minerals	0.42%	0.18%	0.10%	0.52%	1.22%
Basic & Fabricated Metals	1.47%	0.63%	0.36%	1.11%	3.58%
Machinery, Equipment	0.52%	0.22%	0.13%	0.17%	1.04%
Computer, Electronics	2.21%	0.95%	0.55%	1.71%	5.42%
Motor, Transport	0.63%	0.27%	0.16%	0.78%	1.84%
Manufacturing n.e.c.	0.57%	0.25%	0.14%	0.20%	1.16%
Electricity, Water, Gas	0.17%	0.27%	0.33%	1.70%	2.47%
Construction	2.73%	1.18%	0.68%	0.51%	5.10%
Wholesale, Retail	5.00%	5.02%	2.71%	2.48%	15.21%
Hotels, Restaurants	0.63%	0.63%	0.34%	0.18%	1.78%
Transport, Storage	0.89%	0.93%	0.74%	1.68%	4.25%
Telecom, Computer	0.43%	0.45%	0.36%	1.04%	2.28%
Financial Intermediation	0.22%	1.34%	2.15%	4.32%	8.02%
Real Estate Activities	0.09%	0.29%	0.36%	8.75%	9.48%
Other Business Services	0.18%	0.70%	1.17%	0.29%	2.34%
Education, Public Services	2.37%	4.86%	8.54%	3.05%	18.81%
Total: Manufacturing	9.17%	4.40%	2.58%	9.88%	26.02%
Total: Services	12.71%	15.67%	17.36%	23.99%	69.73%
Total: MCEE	2.73%	1.18%	0.67%	1.88%	6.46%
Total: Business Services	3.28%	7.64%	12.57%	17.44%	40.93%
Total	24.68%	20.61%	20.14%	34.57%	100.00%

Notes: The table reports the value-added shares across sectors and factors of production for the Taiwanese economy in 1995.