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The Growth of Chinese Exports:
How Industrial Policy and Good Luck Created a Manufacturing Powerhouse

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Abstract: Over the past decade, Chinese exports have boomed, increasing far faster than GDP growth. What can account for this explosion? Our paper uses finely detailed Chinese export data (8-digit HS codes) combined with U.S. trade data to explore this question. Although exchange rate policy clearly boosted the trade surplus, and the structure of the economy, e.g. abundant cheap labor, encouraged investment, these alone cannot account for the changing composition and acceleration of exports. We find that the growth in exports is most likely a product of effective Chinese industrial policy and fortuitous timing. The detailed trade data reveal that key "new" technology goods, such as cell phones, LCD screens, and laptops played a critical role.

Finally, we use the data to examine the relationship between Chinese exports and U.S. manufacturing employment. We find that increased Chinese competition in both domestic and U.S. export markets likely lowered U.S. manufacturing employment between 2000 and 2007. Chinese policy is not, however, wholly responsible. Some job losses, such as in textile production, were no doubt the result of China's natural comparative advantages. While other U.S. job losses are attributable to relatively low investment and slow GDP growth in the United States following the 2001 recession. Tepid U.S. investment early in the decade also gave China a head start in certain key high-tech industries.

JEL classification: F12, F40, E65

Keywords: China, trade, jobs, exchange rate

*The views in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or of any other person associated with the Federal Reserve System.

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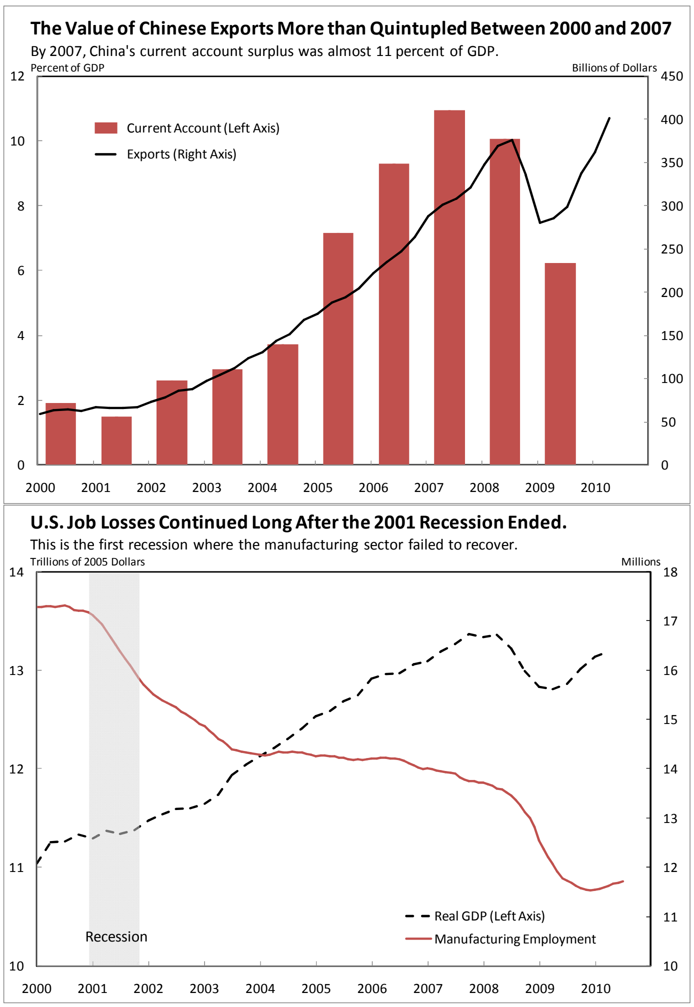
INTRODUCTION

Few people have missed the coincidental timing of the rise of China as an export superpower and the loss of manufacturing jobs in the United States. Between 2000 and 2007, the value of Chinese exports more than quadrupled and rose from 20 percent to 35 percent of GDP (top panel of Figure 1). Moreover, Chinese economic growth became more dependent on external demand, with the current account surplus ballooning from less than 2 percent to a peak of almost 11 percent of GDP. In contrast, over the same period, U.S. manufacturing employment fell by 3½ million jobs, or about 2½ percent of total U.S. employment (bottom panel of Figure 1). Employment in the manufacturing sector declined even as GDP grew and employment outside of manufacturing rose.

Figure 1: U.S. Job Losses Appear Related to China's Exports



Source: U.S. Data: Bureau of Labor Statistics, Bureau of Economic Analysis. Chinese Data: China National Bureau of Statistics.

Popular in the press and amongst a number of U.S. industry groups is the conjecture that China experienced its outsized growth in exports as a result of official support; and, that these exports, serving as substitutes for U.S-based manufacturing, were responsible for the loss of American jobs. A priori, this hypothesis has some appeal. Despite extensive gains toward market determination in recent years, much of the Chinese economy remains state controlled, and China purposefully pushed export-led growth at the expense of domestic consumption.[1]

Although other economies have had success utilizing an export-led growth strategy, such success in a country of China's size is unprecedented. How was China able to accomplish this goal? In this paper, we use finely detailed trade data to differentiate amongst the various reasons given for China's rapid growth of exports. Further, this same data allows us to tell a story linking the rise of China with the decline in U.S. manufacturing.

We conclude that China's usual policy suspects and natural advantages played a role in China's emergence as a manufacturing powerhouse. The exchange rate regime boosted overall exports by subsidizing the export sector at the expense of domestic demand. Heavy industry, such as steel and aluminum production, benefited especially from energy and capital subsidies. Moreover, the expiration of restrictive trade agreements and China's entry into the World Trade Organization allowed it to finally fully exploit its natural advantage in low-skill, labor-intensive industries. However, these explanations are only a part of the story.

Aggregate trade data show that machinery exports accounted for almost half of Chinese export growth between 2000 and 2007. This has been cited by some as evidence of Chinese mercantilism, under the assumption that a developing country is unlikely to be an exporter of capital goods without official support. However, highly disaggregated Chinese trade data, compiled by hand for this paper, show that the growth of Chinese machinery exports was highly concentrated in a few specific high-tech goods—cell phones, LCD screens, and laptops. These goods are largely intended for consumption.

Although, we attribute some of the success of Chinese high-tech exports to industry-specific supports, such as the establishment of science parks, China's export boom likely would not have been achievable without a healthy dose of good luck in terms of timing. First, investment in the West, particularly in the high-tech sector, was severely impaired during the 2001 recession, giving China a head start in key new technologies. Second, global demand skyrocketed over this period for products based on these technologies.

The rapid growth of Chinese exports increased competitive pressure on U.S. manufacturers. For the machinery sector, U.S. manufacturers were particularly disadvantaged as the new products China exported, cell phones, LCDs, and laptops came to dominate globally the broader categories of phones, televisions, computer monitors, and computers in which the United States had a sizable global precence, displacing the

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[1] A goal of China's 10th Five-Year Plan (2001-2005) was to boost its international competitiveness, whereas household income was targeted to fall as a share of GDP. "The 10th Five-Year Plan (2001-2005)," http://www.gov.cn/english/2006-04/05/content_245624.htm

older technologies. Although U.S. job losses in the manufacturing sector during the 2001 recession were in line with previous downturns, U.S. manufacturing employment continued to contract following the recession and never rebounded, leading to the first permanent manufacturing job losses in the post World War II era. These losses were concentrated in those sectors where Chinese exports also grew most rapidly, with more than half of the losses in the apparel and textiles, furniture, metals, and computer industries.

The welfare implications for the United States of the increase in Chinese exports is beyond the scope of this paper, but it is important to note that it is not at all clear that the costs outweighed the benefits. The cost in loss of jobs is obvious, but the benefits included lower prices, more rapid adoption of new technology, and efficiency gains from the removal of trade barriers and through increased competition.

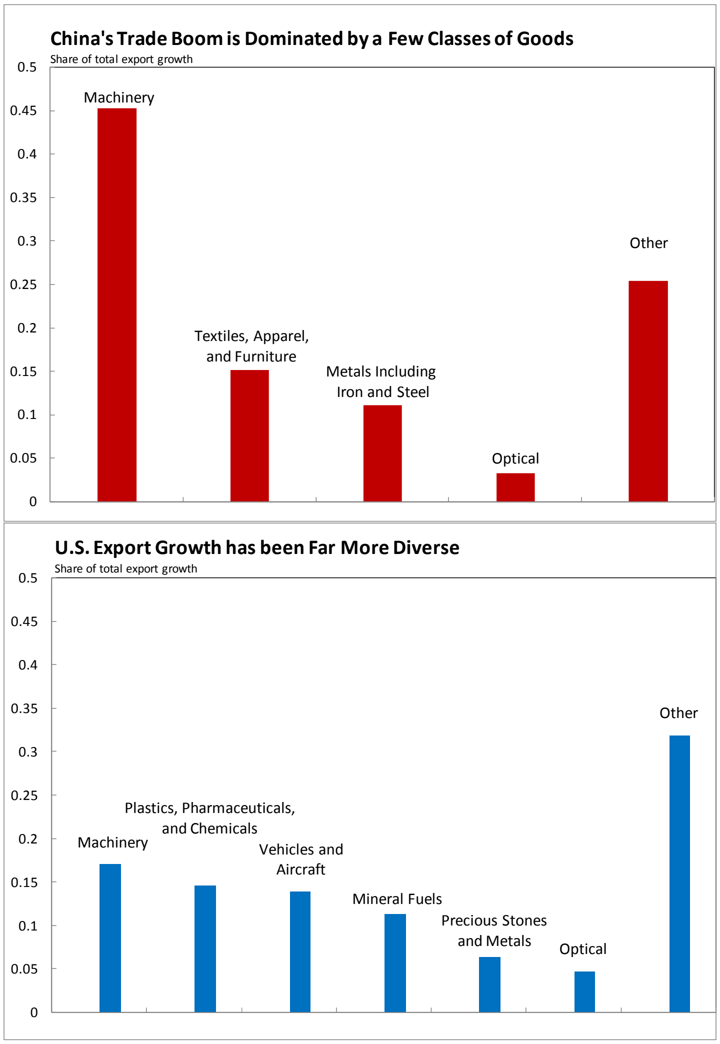
The paper is organized in 5 sections. Section 1 gives some background on the evolution of the Chinese economy and the factors that led to the boom in exports. This section examines Chinese exports at the readily-available 2-digit level of the Harmonized Commodity Description and Coding System (HS), which has been adopted by most countries. Section 2 uses 8-digit HS codes to delve further into the details of Chinese trade. Section 3 develops the facts on U.S. manufacturing employment and details the links between the growth in Chinese exports and the loss of U.S. jobs. Section 4 speculates on the net welfare impact on the United States. Section 5 examines the implications of our research for the prospects of future Chinese export growth and U.S. manufacturing following the 2009 financial crisis. Section 6 concludes.

SECTION 1: THE GROWTH OF CHINESE EXPORTS: AN INITIAL LOOK

In the three decades since economic reforms were enacted in the late 1970s, China has experienced a remarkable period of consistently robust economic growth, with real GDP increasing 20-fold since 1977. The composition of growth, however, has evolved away from consumption over this period. Household consumption fell from an already low 50 percent of GDP in the early 1980s to around 35 percent by the mid-2000s as investment soared and the economy became more export-oriented. This process accelerated significantly at the start of the new millennium. In 2000, China's exports, measured in dollars, were a third of those of the United States and around half of those of Japan and Germany. By 2009, China had become the largest exporter in the world. What can account for this explosion in exports?

To set the stage, Figure 2 shows the composition of Chinese export growth between 2001 and 2007. This growth was dominated first and foremost by machinery exports (HS categories 84 and 85), which accounted for about 45 percent of export growth. Textiles/furniture and metals accounted for 15 percent and 11 percent, respectively. Machinery exports were also significant in U.S. export growth, but accounted for a much lower share of growth than in China and were followed closely by several other categories. The rest of this section examines each of the major categories of Chinese export growth.

Figure 2: China's Export Growth is Less Diverse than in the United States



Source: China Customs (from CEIC) and U.S. Census Bureau.

Textile, Apparel, and Furniture Exports[2]

These categories of exports grew 220 percent from 2001 through 2007. No doubt, trade policy was a primary cause. Prior to China's entry into the World Trade Organization (WTO) in December 2001, China faced apparently prohibitive tariffs and constraining quotas in textile and furniture markets. The production of these goods is intensive in low-skilled labor, an area in which China has an obvious natural comparative advantage.

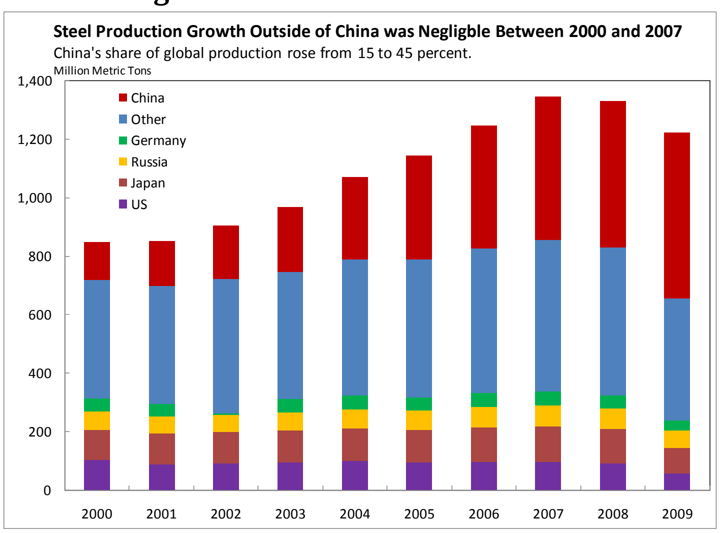
[2] This section includes HS categories 42, 51, 52, 58, 60, 61, 62, 63, 64, 94

Until 2005, Chinese exports of apparel and textiles were limited by a series of gradually less constraining multilateral agreements—the Multifiber Arrangement (MFA, through 1995) and subsequently the Agreement on Textiles and Clothing (ATC). Without these agreements, China's enormous supply of cheap labor likely would have led to a much larger share of the global market earlier. Indeed, Brambilla et al. (2009) found that China was constrained more than any other nation by these agreements. Consequently, when the MFA expired, textile and apparel export growth from China rose, and surged further with the expiration of the ATC. As China gained market share, exports from most other regions declined.

Chinese furniture exports (HS 94), began to increase rapidly back in the early 1990s and accelerated in the 2000s. Mirroring China's export growth, furniture employment in United States fell in the 1990s and the pace of decline picked up in the 2000s. But Chinese competition also impacted other producers. In the early 1990s, Taiwan accounted for a large share of global furniture exports and 30 percent of exports to the United States. By 2007, Taiwan's share of U.S. furniture imports had fallen to 3 percent.

Metals[3]

Figure 3: Global Steel Production



Source: Steel Statistics Yearbook 2010.

In 2000, China was the largest producer of steel, with output 25 percent higher than either Japan or the United States (Figure 3). By 2009, China was producing 6½ times more steel than second place Japan and almost 10 times more than the United States, each of whom have experienced large declines in steel production since the beginning of decade.[4] Overall, Chinese metals exports grew 630 percent from 2001

[3] The metals section includes HS categories 28, 72, 73, 74, 76, 79, 83.
[4] Based on data from the World Steel Association (www.worldsteel.org), Steel Statistical Yearbook 2009.

through 2007. Why would a developing country with an enormous supply of labor experience some of its greatest export growth in a capital and energy intensive industry?

First, energy prices were heavily managed by the government and significantly subsidized. As the 2006 U.S. Manufacturing Energy Consumption survey confirms, iron and steel mills, and aluminum production, are among the largest industrial energy consumers in terms of energy per dollar of value added.[5] Second, the cost of capital for state-owned enterprises (SOEs), which dominate China's heavy industry, was extremely low. SOEs had ready access to bank borrowing at low interest rates because of implicit government backing. Third, the SOEs made substantial strides in improving efficiency and lowering costs. Hsieh and Klenow (2009) estimate that improvements in resource allocation account for about 2 percentage points per year of Chinese total factor productivity growth between 1998 and 2005.

These reforms, which began in the mid-1990s, dismantled the "iron rice bowl," the system of housing, pensions, and health care that accompanied SOE employment. As a result, the SOEs, which were money-losers in the decades prior to reform, began earning substantial profits for the first time. Since SOEs did not pay dividends to the government, they piled up retained earnings and generally had few options but to reinvest the earnings in expanding capacity. This fed a circle in which profits led to greater capacity and still greater profits. From 1995 to 2000, China's steel industry averaged $400 million in annual operating profits and crude steel production rose at an average pace of 6 percent per year. Beginning in 2000, profits and production began to rise rapidly in tandem—profits climbed from $2 billion in 2001 to more than $21 billion in 2007, and crude steel production rose at an average annual rate of 25 percent. Given the incentive structure, i.e. subsidized inputs and political approval of output growth, this reinvestment was optimal from the perspective of Chinese steel producers. Domestic demand could not absorb this massive production growth and China went from being a net importer of steel, as late as 2004, to the largest net exporter in the world.

Machinery[6]

This category of exports grew 520 percent from 2001 through 2007. This is surprising to some trade economists, because, in general, developing economies should be importers not exporters of capital goods. As a result, many economists have attributed much of these gains to China's most visible trade policy, its exchange rate regime. For much of the decade, the renminbi was pegged to the U.S. dollar, and, as evidenced by China's massive accumulation of foreign exchange reserves, authorities have intervened heavily to keep it from appreciating. But the detailed trade data, discussed in the next section, indicate that this was likely not the primary factor in the growth of China's machinery exports.

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[5] http://www.eia.doe.gov/emeu/mecs/mecs2006/2006tables.html (Tables 1.1 and 6.3)

[6] The machinery section includes HS categories 84 and 85.

SECTION 2: Machinery Exports: The Devil in the Details[7]

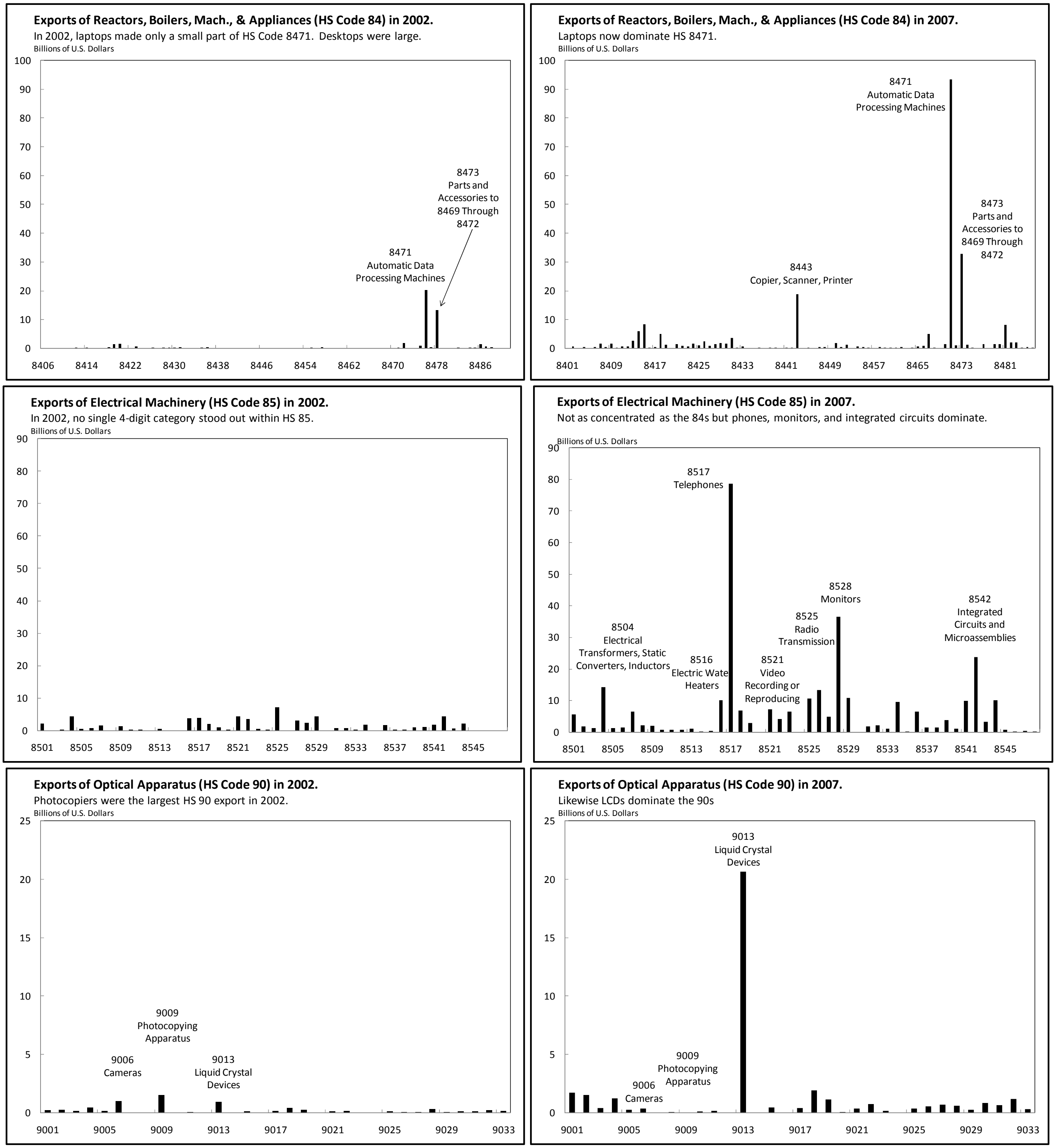
In order to understand the growth of Chinese machinery exports, we now turn to the detailed trade data. Figure 4 shows exports of the machinery categories and the optical category (HS 90) at the 4-digit level; on the left is data for 2002 and on the right is 2007. As the figure illustrates, growth in the machinery categories was highly concentrated in high-tech goods. Digging even deeper, the 8-digit categories, shown in Figure 5, reveal that the growth of machinery exports was dominated by four products—cell phones, liquid crystal displays (LCDs), integrated electronic circuits, and laptops—which together accounted for more than a third of the growth.

This concentration of export growth argues against China's exchange rate regime playing the major role. The exchange rate should have a more-or-less even handed influence across China's export industries, as all goods are made relatively cheaper, and therefore it is not a plausible explanation for the outsized growth of particular categories. Instead, the influence of the exchange rate can perhaps best be seen in the wide range of smaller bars in Figure 4. Most subcategories of machinery exports increased over the period, but their growth was dwarfed by the disproportionate growth of a few categories for which we have special stories. For this reason, we believe papers that explain Chinese trade using more aggregated data, such as Ahmed (2010), Marquez and Schindler (2007), and Thorbecke and Smith (2010) likely overestimate the importance of the exchange rate. But even using the relatively high elasticities common in the literature, the exchange rate would still account for only a minority of machinery export growth over the period. For example, assuming the renminbi became 30 percentage points more undervalued from 2001 to 2007 and the elasticity of Chinese exports was 1½, then the exchange rate would have accounted for less than 10 percent of machinery export growth.

We believe that for laptops, cell phones, LCDs, and integrated electronic circuits, Chinese success owed primarily to state-sponsored investment in the early 2000s and an amazing bout of good luck. In less than a decade, China became the dominant global manufacturer and exporter for each of these products, which share some common characteristics that turned out to favor China. First, they are by-and-large "new" products, incorporating new technologies and production methods. As new products, there was an opportunity for new participants to enter the market and for established participants to open new facilities. Second, they require large capital investments which were likely a barrier to entry for many firms. In particular, high-tech firms in the United States, reeling from the dot-com bust and a capital overhang, were not well positioned to invest. In contrast, Chinese firms and other Asian firms, 5-years removed from the Asian financial crisis, were better positioned. Third, existing production of related technologies was dominated by newly industrialized neighboring countries and Japan, and these countries have historically dominated China's foreign direct investment.

[7] In this section we use data from the China Customs Statistical Yearbooks for 2002 and 2007.

Figure 4: Within 4 and 8 Digit HS Categories Exports are even more Concentrated



Source: China Customs Statistical Yearbooks, 2002 and 2007.

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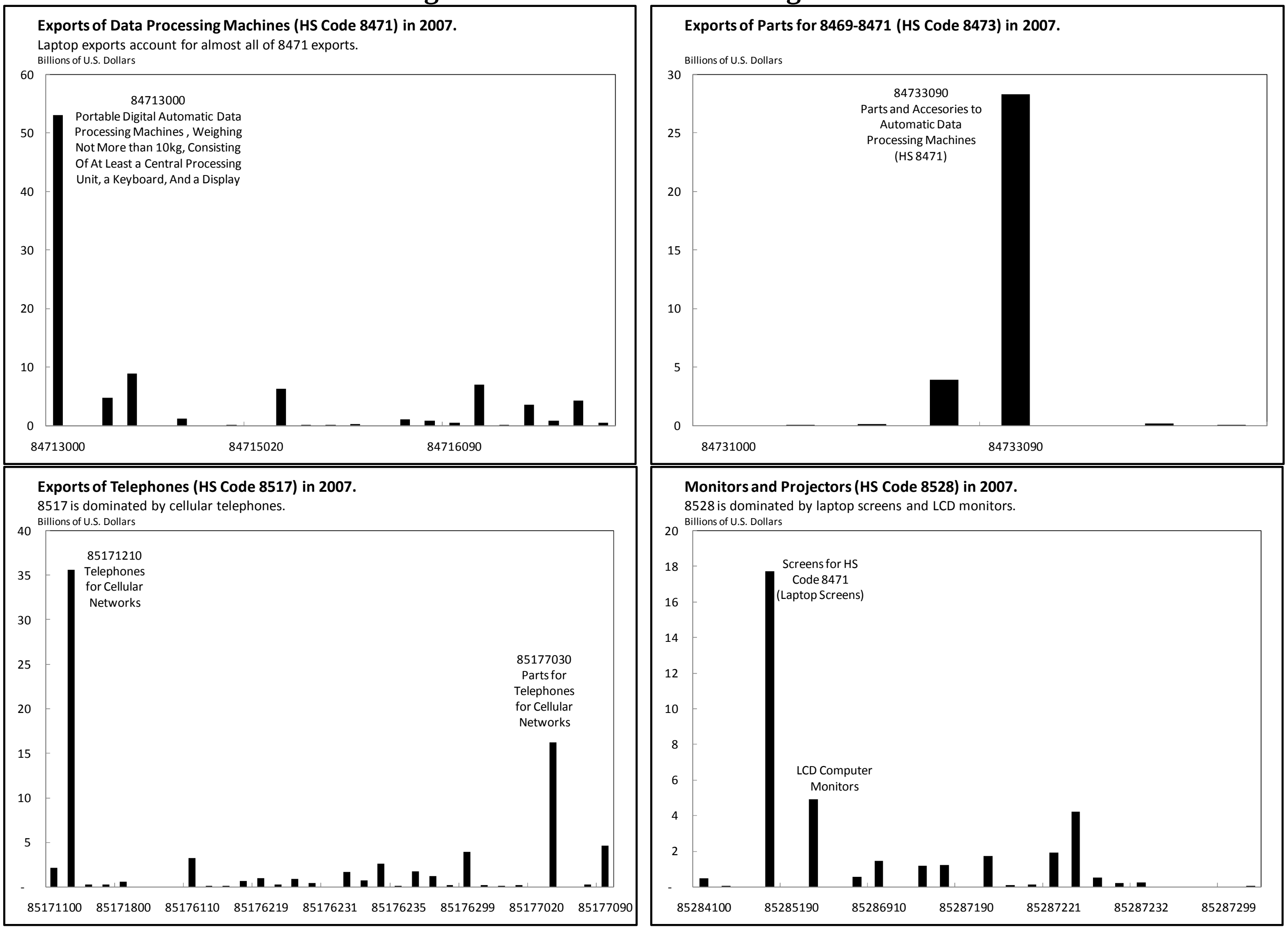
Figure 5: A Glance at the 8-Digit Data



Source: China Customs Statistical Yearbooks, 2002 and 2007.

Fourth, there was an explosion in global demand for these specific products which came to dominate their broader market categories—computers, phones, televisions and computer monitors. Fifth, the leader in the booming global demand for these products was China's own domestic market, where urban disposable income doubled between 2001 and 2007. Not only has China become the leading producer of these products, but over the past decade China has grown from a marginal player to the largest consumer.

Reactors, Boilers, Machinery and Appliances (HS 84)

Returning to Figure 4, the top two panels show the 4-digit subcategories of HS 84 in 2002 and 2007, respectively. The top-left panel looks empty using the scale needed to show the 2007 data, shown to the right. Growth in computers (HS 8471) and associated parts (HS 8473) dominate, accounting for 52 percent of the total growth in HS 84.

These two categories were the largest in 2002 as well, but the composition of the computers making up the categories changed drastically over the period. Portable computers (i.e. laptops) made rapid gains in market share, relative to the traditional desktop computer, over the past decade. In 2002, laptops accounted for 7 percent of HS 8471 exports. By 2007, its share had surged to 42 percent. As shown in the upper left panel of Figure 4, laptops (HS 84713000) were by far the largest subcategory of HS 8471. Similarly, parts and accessories for HS 8471 (HS 8473090) were the largest subcategory of HS 8473 (top right panel).

From 2000 to 2007, during China's export boom, global shipments of personal computers grew 105 percent, with laptops accounting for 47 percentage points of the growth.[8] In 2009, portable computers were estimated to have accounted for the majority of computer shipments for the first time.[9] At the same time, China became the largest producer of laptops, surpassing Taiwan, which had accounted for 64 percent of global laptop production in 2002.[10]

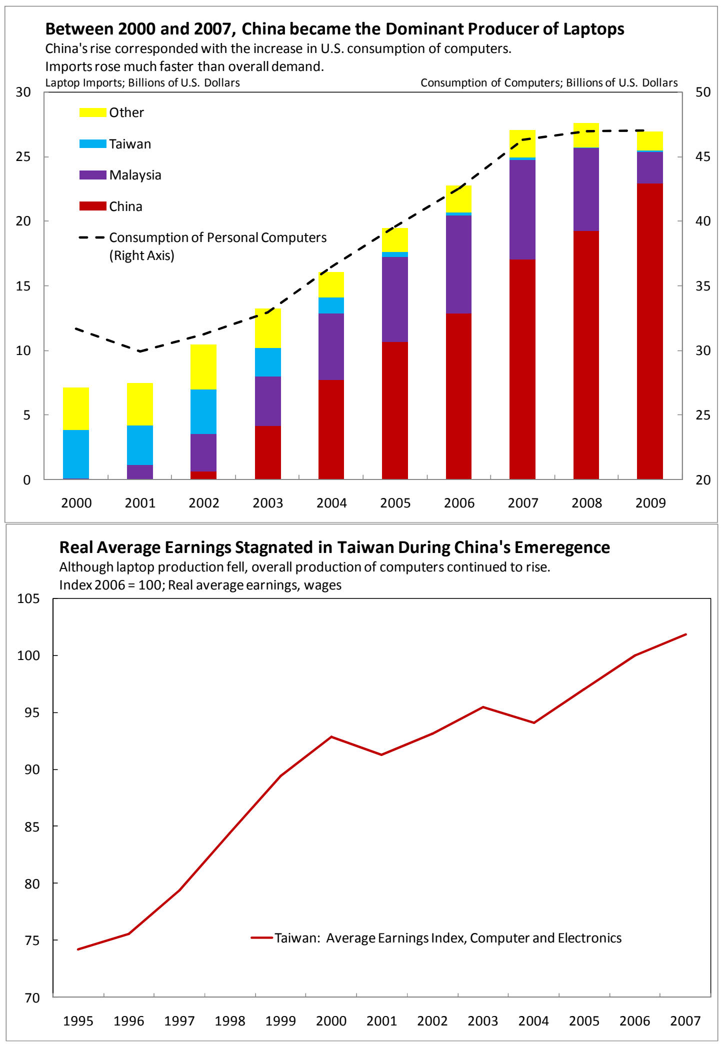
The surge in Chinese exports of laptops was not primarily a case of mainland production displacing other producers, but this was part of the story. Figure 4 shows U.S. imports of laptops by country of origin. U.S. import data reflect the move away from Taiwanese production of laptops to the mainland (Figure 5). In 2000, Taiwan accounted for more than 50 percent of U.S. laptop imports, whereas China accounted for less than ¼ percent. By 2007, China accounted for 63 percent of U.S. imports of laptops, and by 2009 it accounted for 85 percent. Indeed, since 2007, Malaysia and China have accounted for more than 90 percent of U.S. imports of laptops. Nevertheless, through 2007, the value of non-Chinese imports actually increased as the overall market for laptops expanded rapidly. Given the price declines in portable computers over this period, real shipments likely grew even faster. According to China's National Bureau of Statistics (NBS), Chinese production of microcomputers increased from 7 million units in 2000 to 143 million units in 2007.

Government polices helped nurture domestic capabilities in consumer electronics and other advanced areas that would most likely not have developed in their absence (Rodrick (2006)). China's laptop industry, for example, was aided by the creation of "science parks," the development of which have been instrumental in the surge of Chinese high-tech exports generally. Although these parks were originally formed to promote indigenous innovation, they evolved to depend more on foreign investment and technology transfer. As noted in Sutherland (2005), in 2000, the Ministry of Science and Technology and Ministry of Foreign Trade approved a trial for about a third of the parks to become "high-technology export bases."[11] Now, all of the parks have a bias toward this type of production. Foreign investment is drawn to these parks in particular by

[8] Laptop sales data from Computer Industry Almanac (www.c-i-a.com/pr0707) and Gartner (http://www.gartner.com/it/products/newsroom/index.jsp)
[9] International Data Corporation (IDC). http://www.idc.com/getdoc.jsp?sessionId=&containerId=prUS22383910
[10] http://english.peoopledaily.com.cn/200401/08/print20040108_132140.html (cites iSuppli)
[11] Sutherland, Dylan, "China's Science Parks: Production Bases or a Tool for Institutional Reform," Asia Pacific Business Review, Vol. 11, No. 1, pp. 83-104, March 2005.

preferential tax policies. In addition, cheaper labor was a draw for high-tech investment, as in the case for Taiwanese laptop producers. As shown in the bottom panel of Figure 5, between 1995 and 2000, Taiwanese labor costs in computer, electronic, and optical manufacturing rose by more than a third. As high-tech production moved to the mainland, wage growth in Taiwan slowed. Foreign firms were also drawn to China because of the potentially huge domestic market. The Chinese market soared from 21 million personal computers in use at the end of 2000 to 86 million in 2007, second to only the United States.[12]

Figure 6: China as the Low Cost Producer Took Over Laptop Production



Source: U.S. International Trade Commission Dataweb, CEIC.

China's exports of laptops illustrate the one of the primary points of Amiti and Freund (2010), the only other paper we are aware of that used detailed Chinese Customs statistics. Using 6 and 8-digit HS codes, they concluded that Chinese export growth was

[12] Computer Industry Almanac. www.c-i-a.com/pr0608.htm. www.c-i-a.com/pr0701.htm.

mainly accounted for by growth in trade of existing products. Laptops were an existing product, with the first laptop computers manufactured in the early 1980s. However, China's adoption of new technology for producing LCD screens, along with the widespread adoption of wireless technology, moved the laptop from a business-only luxury to a household consumable. In this sense, laptops were a new good in the 2000s.

Electrical Machinery (HS 85)

Electrical machinery exports (HS 85, the middle panel of Figure 3) also grew as the result of new goods. The growth is not quite as concentrated as in HS 84, but it is still dominated by three product categories, phones (HS 8517), monitors and televisions (HS 8528), and integrated electronic circuits (HS 8542). Moreover, the 8-digit data (bottom panels of Figure 4) show that the growth in these categories was also almost wholly accounted for by cell phones, liquid crystal displays (LCDs), and microprocessors and memory. LCD technology also accounted for the majority of the surge in the optical apparatus (HS 90) category (the bottom panels of Figure 3).

Cell Phones

Like for laptops, soaring global and domestic demand fueled China's rise in cell phone production and exports. Global cell phone users rose from about 750 million in 2000 to roughly 4 billion in 2008.[13] Chinese mobile phone subscriptions rose from 85 million in 2000 to around 550 million in 2007 and 750 million in 2009, the largest market in the world. Led by Motorola, all of the major multinational cell phone manufacturers transferred at least some, and in some cases all, of their handset production to China.[14] Although initially dominated by these firms, Chinese companies are gaining market share both at home and abroad. U.S. trade data reflects the growth of the global market and China's market share. U.S. imports of telephone sets rose from $12 billion in 2001 to $55 billion in 2007, with China's share rising from 12 percent to 38 percent (Figure 6).

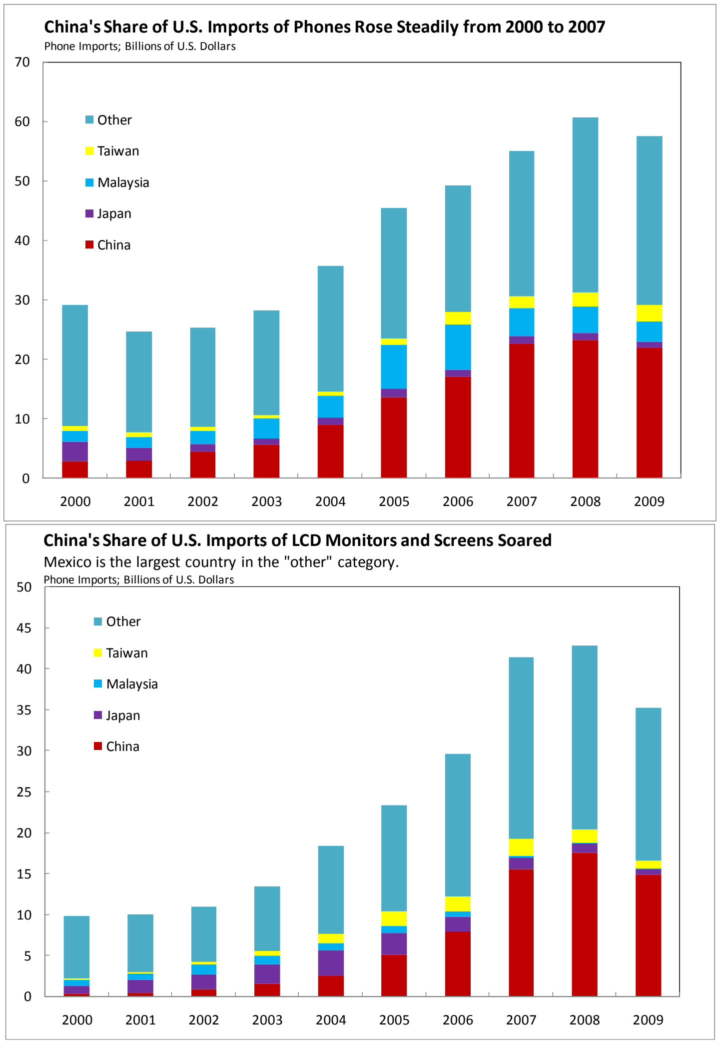
Liquid Crystal Displays (LCDs)

The market for televisions and computer monitors experienced a technical revolution over the past decade. In 2000, cathode ray tube (CRT) technology dominated the two markets. By 2004, LCDs and CRTs each had about half of the global market for computer monitors, but CRTs still accounted for around 90 percent of the television market. However, by 2008, LCDs accounted for more than 50 percent of the television market and, in 2009, around 70 percent.[15] China's NBS estimates that production of color televisions in China doubled from 42 million units in 2001 to 84 million in 2007.

[13] International Telecommunications Union. http://www.itu.int/en/pages/default.aspx
[14] "China's Burgeoning Mobile Phone Industry," China Daily, September 2003. http://www.chinatoday.com.cn/English/e2003/e20039/9p12.htm
[15] Display Search. http://www.displaysearch.com/cps/rde/xchg/displaysearch/hs.xsl/index.asp

China accounted for only 3 percent of the $8 billion in U.S. imports of televisions in 2001. By 2007, 39 percent of the $39 billion in U.S. imports came from China (Figure 7).

Figure 7: U.S. Imports of Phones and LCDs



Source: U.S. International Trade Commission Dataweb.

Integrated Electronic Circuits

Although microprocessors and memory have been a part of personal computers since their introduction in the late 1970s, the rapid turnover of the technology in these products, with new manufacturing processes required for each successive generation, makes them similar to "new" products every few years. For example, between 2000 and 2008, there were 4 different production processes, characterized by ever smaller etching technology, utilized by the main semiconductor manufacturers.[16] Because of the ever-changing technology and highly specialized processes, the capital requirements can be

[16] http://en.wikipedia.org/wiki/130_nanometer

enormous. For example, a new semiconductor fabrication plant can cost as much as $5 billion dollars, with the equipment and necessary inventory holdings costing billions more.[17] To be profitable, the plants need to run at high volumes. According to the NBS, Chinese production of semiconductor integrated circuits increased from less than 6 billion pieces in 2000 to 42 billion pieces in 2007.

Unlike for the other categories of exports discussed, the United States is not one of the primary markets for Chinese exports of integrated circuits. U.S. imports of integrated circuits have remained relatively flat since 2002 at around $22 billion, with China accounting for only $1.4 billion in 2007. This is likely because integrated circuits are an intermediate good, with China primarily exporting them to other countries as a step in the production process, thought the United States may well be the primary market for the final product.

SECTION 3: The relationship between U.S. Manufacturing and Chinese Exports

The manufacturing sector has been shrinking as a share of the U.S. economy since the early 1970s, but through 2000 real manufacturing production continued to climb and employment in the manufacturing sector remained stable except for fluctuations correlated with the business cycle (Figure 8, top panel).[18] However, between January 2000 and December 2007, manufacturing employment in the United States fell by 3.6 million, nearly 21 percent, to 13.7 million.

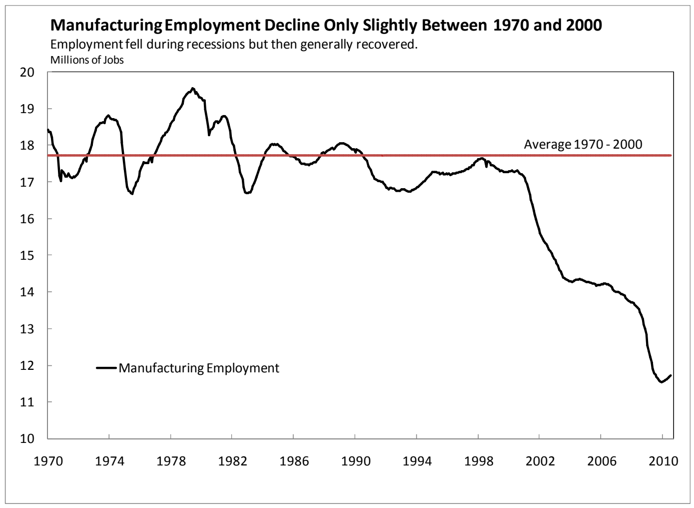
No doubt some of these losses are attributable to the 2001 recession. But as shown in the bottom panel, overall manufacturing job losses *during* the 2001 recession were not unusual by historical U.S. standards. The figure plots manufacturing employment in the months centered around recession troughs (as designated by the NBER), indicated by the vertical line. The blue line corresponds to the average experience over the post-war recessions prior to the 2001 recession, which is plotted as the red line. The pattern of manufacturing employment was very typical prior to the recession and through its trough, but atypical from that point onward. In the past, manufacturing employment began to rebound within 6 months of the trough, but following the 2001 recession, manufacturing employment contined to fall for 2 years and then only flattened out rather than recover. Chinese exports, competing with U.S.-produced goods in the domestic and foreign markets, can perhaps account for part of this unusual pattern.

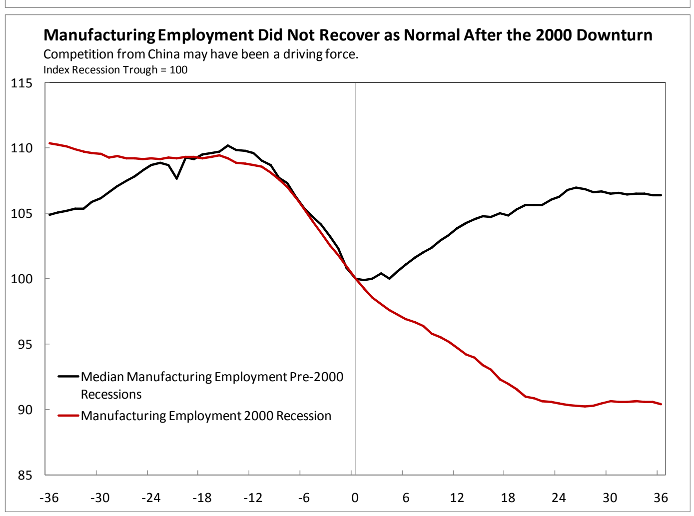
Employment in the metals and minerals industries fell by more than 400 thousand between 2000 and 2007. Competition with China and inovation in mill technology forced a massive reorganization of the steel industry during this period. Production of steel moved from massive steel plants, producing a broad range of steel products, to more

[17] http://spectrum.ieee.org/semiconductors/design/the-new-economics-of-semiconductor-manufacturing
[18] Give BEA source for these statistics. Give correlation of real GDP and manufacturing employment 1970-2000.

efficient, specialized mini-mills. According to the Economic Census, the number of iron and steel mill establishments rose from just under 300 in 1997 to 445 in 2002, even as employment at these mills fell by almost 20 percent. As noted above, production of steel was flat over the ten years between 1997 and 2007, implying an increase in output per employee of about 4 percent per year. The new steel mills built in the late 1990s were sufficiently productive to remain in business despite Chinese competition. However, in the absence of capital and energy subsidies, U.S. industry was not sufficiently profitable to expand to meet the growth in global demand in the 2000s.

Figure 8: The Level of Manufacturing Employment was Steady Until 2000

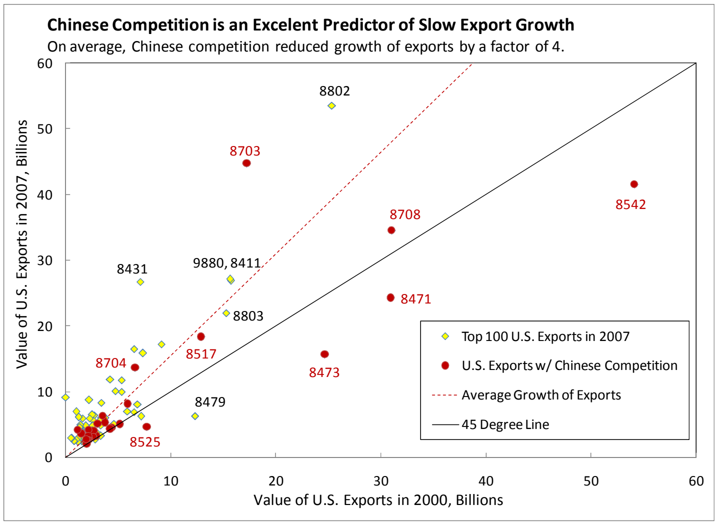




Source: Bureau of Labor Statistics.

The old-line U.S. steelmakers, losing market share and with higher wage, health, and retirement costs, experienced a string of bankruptcies beginning in the late 1990s, leading to industry and union pressure for protective tariffs, which were imposed by President George W. Bush in 2002 on most steel from non-NAFTA industrialized nations. Later reduced, the tariffs were found in 2003 to be illegal under World Trade Organization rules, and President Bush reversed the tariffs.

Figure 9: Chinese Competition with U.S. Exports



Source: U.S. International Trade Commission Dataweb.

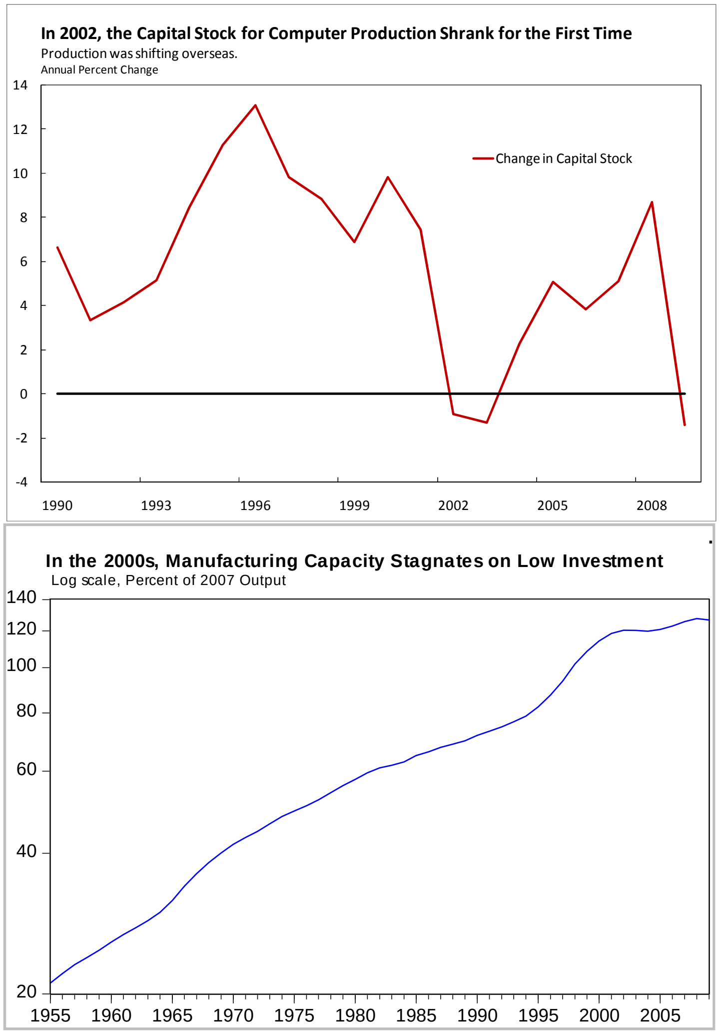
Increased competition from China in U.S. export markets is illustrated in Figure 9. Each point of the scatter plot represents the value of U.S. exports in 2000 and 2007. The points are drawn from the 100 largest 4-digit HS categories in 2007. We shaded a point red if that category was also one of the top 50 categories of Chinese export growth measured in dollars. The red dots primarily fall below the trend line, the dashed, red line. Moreover, the red-shaded points that fall below the 45 degree line, indicating that those categories fell in dollar value between 2000 and 2007, are all high-tech goods.

Of course, these high-tech categories, in particular HS 8542, HS 8471, and HS 8473, evolved over this period, such as the move from desktops to laptops. The United States was clearly capable of making this transition but did not make the capital investment in the early 2000s to do so because of the bursting of the tech bubble and ensuing recession. In 2002 and 2003, the stock of private fixed assets in the computer and electronics industry fell for the first time in the postwar era (Figure 10, top panel). In contrast, Chinese investment in high-tech was soaring. Chinese fixed asset investment in communications, computer, and other electronics industries doubled between 2004, the first year of available data, and 2007.

In fact, lackluster overall investment by the United States led to the smallest 10-year increase in manufacturing capicity since at least 1955 (bottom panel). The absence of capicity growth appears to have hindered the rebound in employment typically experienced following a recession. Of course, it is difficult to determine whether U.S. investment was lacking *because* of Chinese competition or whether the lack of investment opened the door to said competition. But regardless of the cause, with U.S.

manufacturing capacity stagnant, there was an opportunity for Chinese producers to gain market share, both of the U.S. import market and the global market. The share of U.S. imports from China doubled from 8¼ percent in 2000 to 16½ percent in 2007.

Figure 10: Lackluster U.S. Investment in the 2000s

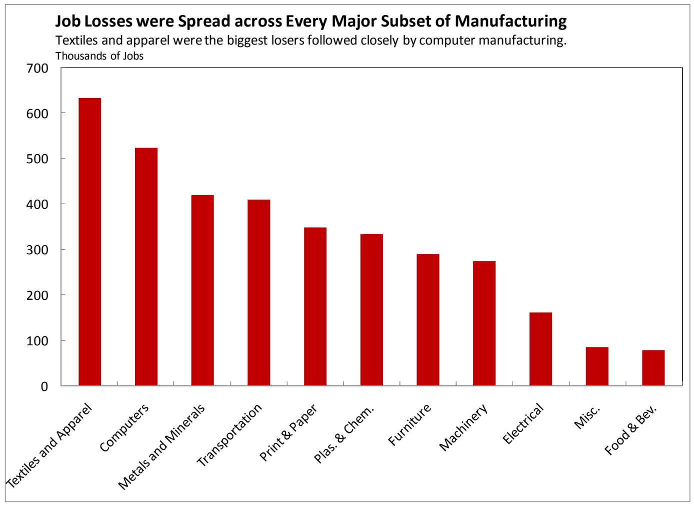


Source: Bureau of Economic Analysis.

Qualitatively, the relationship between job losses in the United States and Chinese exports seems clear. As shown in Figure 11 below, the composition of job losses mirror the industries in which Chinese exports increased most robustly. The sectors with the largerst losses, textiles and apparel, computers, metals and minerals, and the furniture industry together accounted for about half of total job losses.

Preliminary: Please do not cite or quote without permission.

Figure 11: Employment Losses by Industry



Source: Bureau of Labor Statistics.

Back-of-the-Envelope Estimation

The trade data weaves a convincing picture of a relationship between China's emergence as a global producer and the decline of manufacturing employment in the United States. To better quantify the different forces affecting U.S. employment, we run a simple regression and conduct a basic counterfactual exercise.

First, we explain the historical pattern of manufacturing employment using key macroeconomic indicators. We regress the log difference of quarterly manufacturing employment on a constant, and the log differences of U.S. GDP, foreign GDP (weighted by U.S. exports), and investment in equipment and software (E&S). The right-hand side variables were estimated using third degree polynomials of four lags. We also include a first-order autoregressive error term, AR(1). The results are reported in Table 1, with the statistics for the sum of the lags reported for the economic variables. We estimated the equation through 1999:Q4 in order to allow for out-of-sample forecasts from 2000 forward, our period of interest.

Table 1

Dependent Variable: Log-difference Manufacturing Employment

Variable	Coefficient	Std. Error	t-Statistic
C	-0.015	0.002	-7.747
US GDP	0.604	0.277	2.182
For GDP	0.948	0.256	3.712
E&S Inv.	0.112	0.074	1.517
AR(1)	0.319	0.096	3.319
R^2	0.816		
Adj. R^2	0.791		

*Independent variables are log differences.

The coefficients on the GDP variables are of the expected sign and statistically significant at the 5 percent confidence level. The coefficient on investment falls just short of signficance at the 10 percent level. The inclusion of the autoregressive term has little impact on the coefficients and significance of the other variables as its relatively low value would suggest. In Figure 12, we show dynamic forecasts of the model through the 1980 and 1990 recessions. The model does a very good job of capturing both the contours and levels of employment, despite the very different characteristics of the two recessions.

Figure 12: Despite Different Shapes, the Model Fits Well in 80s and 90s

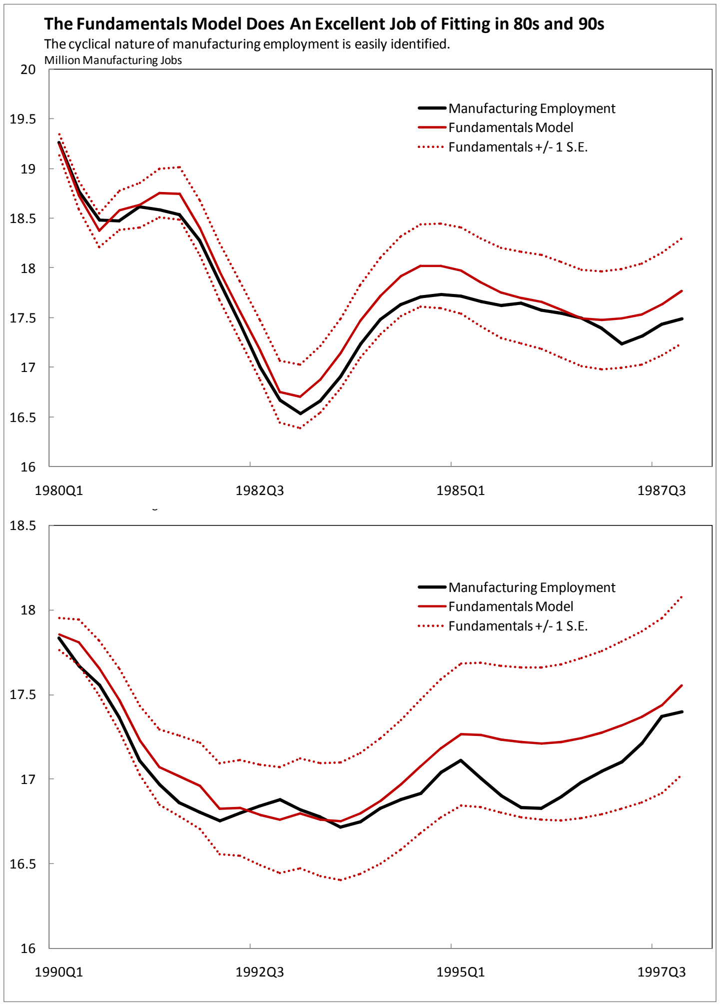
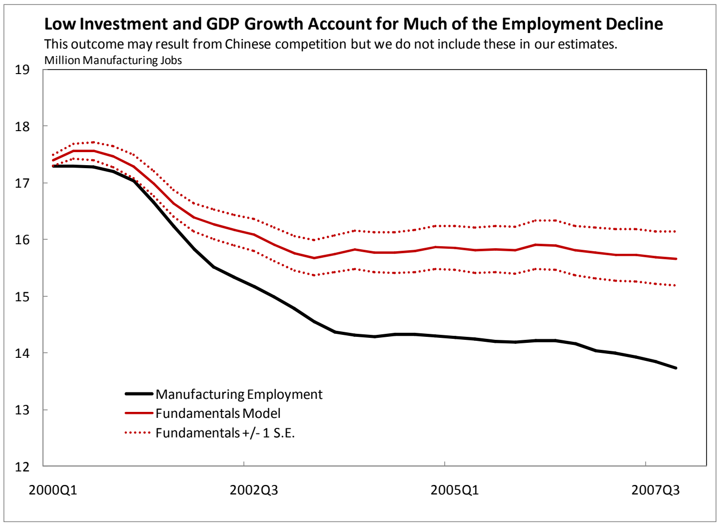


Figure 13 shows our out-of-sample forecast for manufacturing employment from 2000 through the fourth quarter of 2007. The model matches the general shape of employment through this period but significantly underestimates the job losses from the trough of the recession in the fourth quarter of 2001 through the end of 2003.[19] We could

[19] The same exercise done in-sample produces essentially the same result.

not find a domestic macro variable capable of explaining the gap between the model fit and the data. It is important to note that the model shows that even after the recession's trough, U.S. GDP and investment growth were not sufficiently robust to prevent a decline in employment over the next two years. Moreover, after employment stabilized, these variables were not strong enough to produce a substantive rebound.

Figure 13: A Fundemantals Model of Manufacturing Employment



A clear missing component is a variable on Chinese trade (given this is a paper on China). Ideally we would measure for China's impact on the United States using the share of Chinese exports in global exports to capture China's competition with U.S. goods in both the domestic market and in U.S. export markets. Unfortunately, the Chinese export data is only available starting in 1984. This is problematic because it excludes the 1974, 1980, and 1982 recessions leaving only one downturn in the sample. Hence, regressions using Chinese exports estimated through 1999:Q4 are unable to capture the cyclical properties of manufacturing employment.[20]

U.S. trade data by country is available back to the early 1970s. Therefore, we use the Chinese share of total U.S. imports as a proxy for China's global export share. The results of this regression are shown in Table 2. Chinese imports come in with a negative sign and is statistically significant. The out-of-sample forecast is shown as the solid, red line in Figure 14. The addition of Chinese import share allows the model to fit better during the recession and to decline at approximately the same rate as the data thereafter. The data stay within one standard deviationof the model, the dotted red lines, for almost the entire forecast period.

[20] The Chinese share of global exports is statistically significant in regressions like that in Table 2 estimated through 2007:Q4, which include the 2001 recession.

Table 2

Dependent Variable: Log-difference Manufacturing Employment

Variable	Coefficient	Std. Error	t-Statistic
C	-0.011	0.002	-5.373
US GDP	0.341	0.254	1.341
For GDP	0.802	0.240	3.344
E&S Inv.	0.183	0.071	2.576
Chin. Imp. Shr.	-0.062	0.030	-2.088
AR(1)	0.209	0.093	2.254
R^2	0.830		
Adj. R^2	0.795		

To complete the exercise, we conduct a counterfactual experiment. Rather than allow the share of imports from China to increase over the forecast, we hold them constant at their 1999:Q4 level. The results of the forecast based on a flat Chinese import share are shown by the blue, dashed line. Under this counterfactual, by the end of 2007, U.S. manufacturing employment would have been 1.2 million jobs higher than our baseline estimate. Therefore, we conclude that the outsized growth in Chinese exports accounted for about a third of the total manufacturing job losses over this period. Of course, this counterfactual does not take into account the effect of China on U.S. GDP and U.S. investment, holding down our estimate of the overall impact.

Figure 14: Model Inferred Job Losses

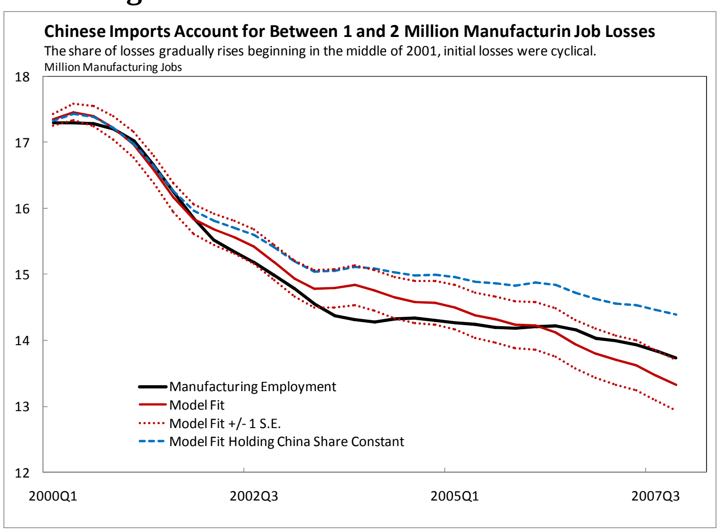


Table 3

Dependent Variable: Log-difference Manufacturing Employment

Variable	Coefficient	Std. Error	t-Statistic
C	-0.013	0.002	-6.080
US GDP	0.533	0.273	1.955
For GDP	0.900	0.293	3.076
E&S Inv.	0.088	0.070	1.263
U.S. Imp. China	-0.009	0.016	-0.590
AR(1)	0.352	0.111	3.179
R^2	0.818		
Adj. R^2	0.780		

*Independent variables are log differences.

A reasonable question is how the results would differ if we used a different specification of the model, such as log-differenced Chinese imports rather than the Chinese share of U.S. imports. The results of this regression are shown in Table 3. In this specification, imports from China are not statistically different from zero. We believe there are primarily two reasons for this result. First is an issue of scale. In this regression, import growth of 20 percent in 1975 is given the same weight as 20 percent growth in 1995 even though the 1970 growth represents less than ½ percent of the dollar value of the 1990 growth. When rapid Chinese trade growth represented a small fraction of the U.S. and global economies, it is not surprising that it had a small impact on U.S. manufacturing. Second, there is a pro-cyclical component to U.S. imports that is not fully captured by the GDP variables. When the economy is growing and employment rising, imports in general, including those from China, tend to increase. Hence, the negative effect on employment of Chinese exports gets offset to a degree from this cyclical component. It is possible to quibble with our choice of a scaling variable, but one obtains similar results to ours if imports from China are instead scaled by U.S. GDP.

An Examination Industry-by-Industry

A shortcoming of the above exercise (and a reason we refer to it as back of the envelope) is that China's emergence is a single event. Although we conducted an out-of-sample estimation, a supplementary exercise exploiting cross-section aspects of trade and employment at the industry level can shed light on the severity of the identification problem. In essence, exercise tests the qualitative analysis on the relationship between trade and jobs shown at the beginning of the section.

China's export growth was not evenly distributed across industries. Some industries, textiles and computers for example, grew much faster than the average. A reasonable expectation is that those industries experiencing the greatest competition from Chinese production are likely to experience the greatest job losses. We test this, industry by industry, at the 3-digit NAICS code level.

We use U.S. domestic demand by industry as an instrument for global demand and Chinese exports to the United States as a proxy for total Chinese exports. Of course, the instruments are not perfect. In partiuclar, this data may fail to capture Chinese competition with U.S. exports.

To properly scale Chinese import penetration, we construct a measure of domestic demand by industry. U.S. domestic demand is defined as industrial production minus the change in inventories minus exports plus imports. Import penetration is then defined as the ratio of imports to domestic demand.

Table 4

		Cummulative Impact of Import Penetration on Jobs*					
		Chinese Jobs Impact	World Jobs Impact	Chinese Imports	T-Stat	World Imports ex China	T-Stat
Panel Estimate		**-788**	**464**	**-2.89**	-2.6	**8.39**	4.3
Industry Estimates							
311	Food	12	-26	1.14	0.2	-7.03	-0.9
312	Bev. and Tobacco	0	-6	**4.15**	1.7	-8.99	-0.6
313	Textiles	8	4	3.45	0.7	7.82	0.5
314	Txtl. Mill Products	-46	9	**-34.85**	-2.6	15.37	1.0
315	Apparel	-25	1	**-8.30**	-1.3	0.70	0.1
316	Leather	-13	4	**-50.31**	-1.7	19.90	0.7
321	Wood	32	6	**10.85**	1.4	**19.54**	7.6
322	Paper	-29	3	**-8.07**	-1.4	5.34	0.7
323	Printed Matter	-8	0	-2.14	-0.3	0.02	0.0
324	Petroleum	0	0	0.22	0.2	-2.08	-0.4
325	Chemicals	-8	8	-1.66	-0.9	4.62	0.9
326	Plastics	38	-13	8.84	0.6	-7.03	-0.3
327	NonMetal Mineral	-16	19	**-13.60**	-1.8	**42.87**	6.7
331	Primary Metal	-1	18	-0.28	-0.1	8.28	1.3
332	Fabricated Metal	-242	155	**-29.04**	-3.5	**41.98**	3.9
333	Machinery	-123	71	**-16.16**	-2.5	**30.02**	3.6
334	Computers	-149	39	-13.41	-0.5	16.83	0.8
335	Electrical Equip.	-26	47	-11.25	-0.6	**30.06**	1.5
336	Transportation	24	16	2.28	1.0	**17.17**	1.5
337	Furniture	-6	13	-2.24	-0.2	17.73	1.0
339	Misc.	-18	19	**-9.23**	-2.9	**9.83**	2.0

* Percent change in employment to a percent change in import penetration

We estimate the impact on jobs by regressing, industry by industry, the log change in employment on the log change in Chinese import penetration, the log change in import penetration excluding China, and the log change in industrial production. The last four columns o f table 4 show the results from this exercise.

The first line of the table shows the results for a panel regression with industry fixed effects. A one percent increase in Chinese import penetration reduces employmnet across these manufacturing sectors by almost 3 percent. In contrast, the same increase in import from other countries boosts employmnet by over 8 percent. Both coeficients are highly statistically significant. Moving down the table, the results appear for each industy. Here the regressions are conducted one industry at a time. Numbers highlighted in bold are statistically signifcant.

The first two columns of the table highlight the estimate impact on jobs by sector. The number takes the coeficient on the relevant varialbe and multimplies it by the change in that variable between 2001 and 2007. This estimate of the total percent change in jobs over the period is then applied to base employment in that sector in 2001. The estimated job losses are concentrated in three industries. Fabricated metal, machinery, and computers. These three industries have relatively large coefficients and were large employers in 2001. The total impact estimated using the panel coeficitnet is about 800 thousand jobs, a number just shy of the 1 million we obtained in our counterfactual excersise above.

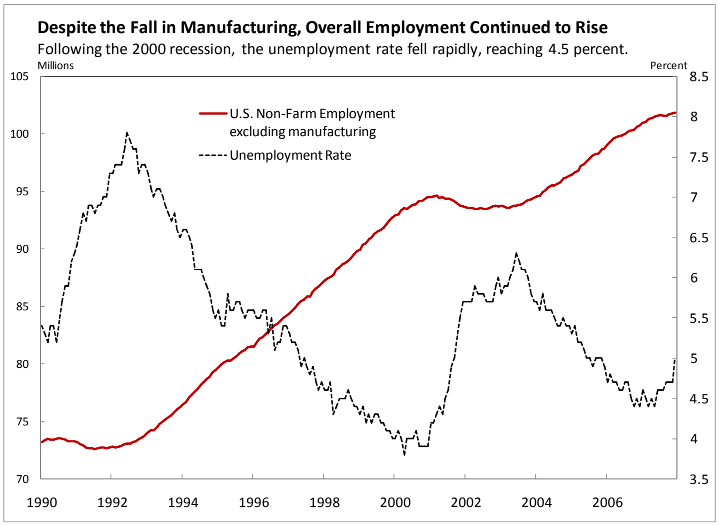
SECTION 4: The Benefits of Trade with China

We have shown that the emergence of China as a global manufacturing producer reduced manufacturing employment in the United States. These employment losses result in a welfare loss to the United States and particularly to these workers; however, they may also signal the benefits from trade and specialization. The most fundamental tenet of trade is that of comparative advantage. A natural consequence of China's emergence is industrial reorganization. However, losses in one industry and amongst one class of workers in no way imply net welfare losses in the United States as a result of the emergence of China.

Trade generates substantial benefits to countries and trade with China has not been an exception to this rule. Many of the manufacturing job losses occurred in industries where the United States was already (pre-China) not naturally competitive. The textile industry was in decline well before 2000. And, the trade protections that had propped up the U.S. textile industry were gradually diminishing and textile production was moving to countries with cheaper labor. China's emergence merely accelerated this process.

Indeed, as shown in Figure 15, for every job loss in the manufacturing sector, the rest of the economy created more than one job, implying that the economy as whole was able to absorb the displaced workers. U.S. non-farm employment excluding manufacturing rose from 93 million in 2002 to over 100 million in 2007, a gain much larger than the 3 million job loss in the manufacturing sector. Perhaps more importantly, job growth was sufficiently fast to push the unemployment rate down to well below its average of the 1990s and within ½ percentage point of its all time low in early 2000.

Figure 15: Total Employment and Unemployment



Source: Bureau of Labor Statistics.

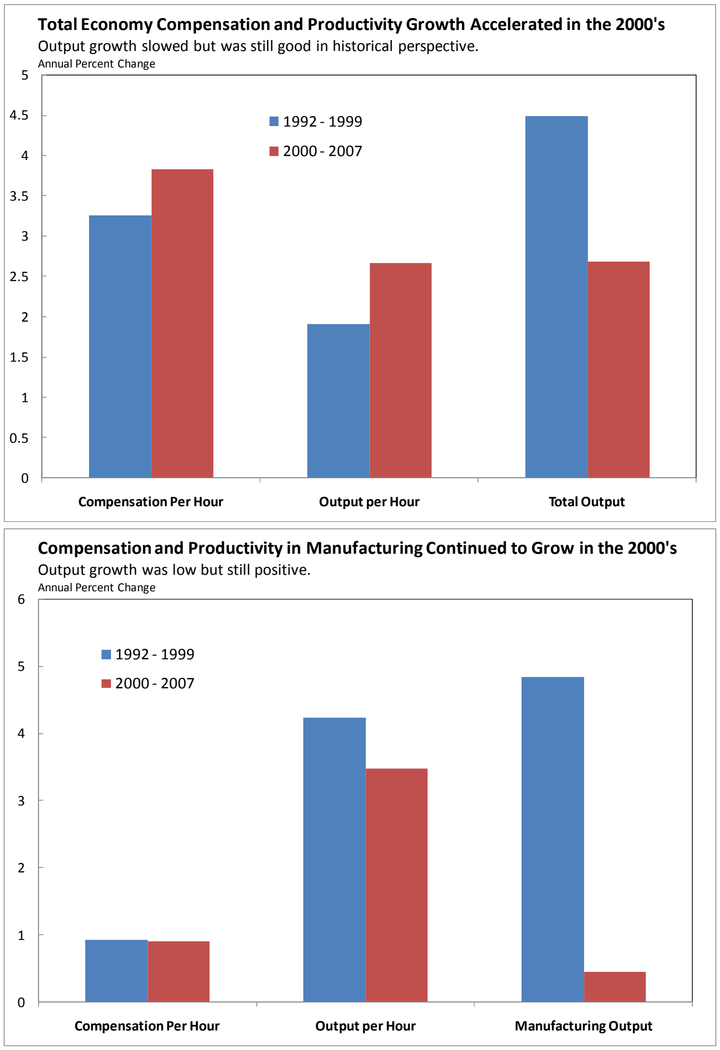
Of course, even if all the labor was absorbed, the United States could still have suffered a welfare loss if these workers were forced out of manufacturing into less productive industries—that is, post-China comparative advantage in the United States could have been concentrated in industries with low absolute levels of productivity. Figure 16 provides evidence that this was not the case.

The top panel of Figure 16 compares the growth rate of real compensation per hour, real output per hour, and total output between the periods 1992-1999 and 2000 to 2007 for the economy in its entirety.[21] Both compensation per hour and output per hour (a broad measure of productivity), increased at faster rates in the 2000s relative to the 1990s, with compensation growing 17 percent faster and productivity a whopping 40 percent faster. Total output growth slowed relative to the 1990s but remained only a hair below its post-1980 average annual growth rate of 2.8 percent.

The gains in productivity in the 1990s appear to be associated with an increase in the share of high-productivity services sector jobs. Even before the emergence of China, the United States experienced a major shift of production and employment from goods-producing industries towards services (Van Ark et. al., 2008). This general trend seems to have accelerated in the 2000s. The growth in compensation per hour implies that these gains were shared between firms and workers.

[21] The comparison is biased towards finding higher growth in the 1990s because the early sample begins after the 1991 recession while the latter sample includes the 2001 recession.

Figure 16: Compensation and Output per Hour



Source: Bureau of Labor Statistics.

More importantly, even in manufacturing, the growth rate of compensation per hour and output per hour in the 2000s was comparable to their growth rates in the 1990s. Therefore, the average surviving manufacturing firms were more productive in 2007 than the average manufacturing firm in 1999 and despite the increase in available supply of manufacturing workers; the growth rate of compensation per hour did not fall. Of course, manufacturing output stagnated in the 2000s, but this stagnation is a symptom of the shift in industrial structure not a positive or a negative for the United States in and of itself.

In addition, the increase in Chinese production likely had a beneficial impact on U.S. consumer prices. Kamin et al (2006) estimated that for every percentage point increase in China's import share, import price inflation is reduced by about 1 percentage point. According to this estimate, the increase in China's import share between 2000 and 2007 reduced the 2007 level of import prices by about 8 percent.

SECTION 5: Implications for the future

U.S. investment in the latest global recession again has been lackluster. Like in the early part of the 2000s, the stock of high-tech fixed capital fell in 2009 and likely has fallen in 2010 as well. This may once again open the door for new technologies to be dominated by foreign producers. U.S. manufacturing employment has fallen by 2 million since the first quarter of 2008. Like in the previous recession, the downturn in investment may limit the potential for a rebound in employment. Our model, estimated through 2007:Q4 would have predicted about half a million more job losses through the second quarter of 2010 than actually occurred. Thus far, our model attributes 100 thousand of the 2 million job losses to China (calculated by keeping China's import share constant at its 2007:Q4 level). This is a very similar percentage to what the model would have predicted four quarters following the trough of the 2001 recession.

The IMF and others project China's trade surplus will again surge. For example, in its 2010 Article IV for China, the IMF projects the surplus will grow rapidly to an astonishing $640 billion by 2015, triple the level they expect for 2010. But which sectors will generate the needed export growth?

For apparel, furniture, and steel, it is unlikely that China will be able to repeat the massive surge in exports experienced earlier this decade. China now has a high market share in these categories and the categories themselves are unlikely to experience tremendous growth. In addition, Chinese authorities are making some efforts to increase the energy efficiency of the economy, including discouraging growth in energy-intensive industries such as steel and aluminum.

For high-tech products, China may be able to repeat its success, but it will be difficult. For example, China already produces most of the world's laptops. For some of the products discussed, there may be some room for China to increase market share further, but China's ability to gain additional market share in these now more mature markets, with more established players, is far from certain. In addition, the probability of China picking the next game-changing technology is low.

A final point is that, no matter the sector, there must be an importer on the other side of China's exports. If the Chinese trade surplus increases by $400 billion, then the rest of the world's deficit must also increase by that sum. This notion often gets swept under the carpet. For example, the IMF's April 2010 WEO projects the current account surplus of the emerging and developing countries will increase by $350 billion between 2010 and 2015 but that the deficit in the advanced economies will increase by less than $200 billion—45 percent of the surplus is added to the statistical discrepancy.

SECTION 6: Conclusion

This paper examines the underlying causes of China's rapid growth of exports over the past decade. An undervalued exchange rate likely contributed to a degree, but export growth was relatively concentrated in select industries when one would expect the exchange rate to have a broader impact. Labor-intensive industries such as apparel, textiles, and furniture, benefited from China's WTO ascension. The apparel and textile industries saw massive gains following the expiration of multilateral agreements which had limited China's exports. Capital and energy-intensive industries, particularly iron and steel, benefited from government subsidies. These industries also benefited from Chinese industrial policy that led to state-owned enterprises becoming increasingly profitable. These profits combined with capital restrictions on SOEs resulted in an expansion of capacity and production beyond the domestic market's ability to absorb it.

These explanations, however, can take one only so far, as nearly half of Chinese export growth occurred in the "machinery" categories. It is only by examining more detailed Chinese trade data that one can see that this growth was heavily concentrated in a few specific high-tech products—cell phones, laptops, liquid crystal displays, and integrated electronic circuits. China was able to rapidly increase its exports of these products because of: industrial policy, such as science parks, that specifically encouraged these types of exports; an explosion in global demand for these products, with Chinese domestic demand leading the way; and, finally, a sharp fall in U.S. high-tech fixed investment, which contributed to China's ability to dominate these new technologies.

Further, we have linked the surge in Chinese exports to a fall in U.S. manufacturing employment in the United States. Our calculations show that macroeconomic fundamentals explain only part of the fall in manufacturing employment between 2000 and 2007, and that Chinese exports can help account for the remainder. Our analysis indicates that in the absence of China's emergence as a global producer, U.S. manufacturing employment would have likely been about 1 million higher. In other words, in the absence of China's emergence, U.S. employment would have been about ¾ percent higher in 2007.

However, as we have noted earlier, quite a number of the jobs lost over this period, particularly in the textile, apparel, and furniture industries, would have moved to China earlier, owing to its natural comparative advantage in labor-intensive production, if not for protective tariffs and trade agreements. Chinese industrial policy aided the country's exports of high-tech goods, but China was also able to gain a competitive position in key products because it invested heavily at a time of burgeoning global demand for these products and diminished U.S. investment. More importantly, the loss of manufacturing jobs does not equate to a welfare loss for the United States as a whole. Trade with China has generated substantial benefits to the United States, including lower prices, faster productivity growth, and an increase in variety in consumer goods.

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