

## The Geography of Trade and Technology Shocks in the United States<sup>†</sup>

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The United States and many European countries have experienced growing income inequality and increasing employment polarization (i.e., concentration of employment in the highest and lowest paid occupations) over the past several decades (Autor, Katz, and Kearney 2008; Dustmann, Ludsteck, and Schönberg 2009; Goos, Manning, and Salomons 2012). The two most prominent potential causes for these “effects” are rapid technological change (e.g., the computer revolution) and expanding international trade (e.g., the rise of China). There is also a growing sense that trade and technology are a unified force affecting labor markets. Commencing with the work of Blinder (2009), economists have posited that job tasks that are suitable for automation may also be suitable for offshoring.<sup>1</sup> However, not all work processes are equally susceptible to trade and technology. Many labor-intensive tasks that have proved challenging to automate can nevertheless be readily performed overseas. Consequently, substantial pieces of production chains have already moved to the developing world. But there are many labor-intensive tasks, such as janitorial

services and package delivery, that must be performed in person or in close proximity to customers, and hence are not readily susceptible to international trade. Thus, for example, while short order cooks at restaurants face little competitive threat from overseas workers, it is now commonplace for grocery stores to carry prepared meals that are cooked and packaged overseas.

The objective of this paper is to explore the geographic overlap of trade and technology shocks in US local labor markets. If the overlap is extensive, there would be a strong case for viewing trade and technology as phenomena whose consequences cannot be distinguished. However, if the evidence reveals only limited overlap, trade and technology may be playing substantively different roles in shaping labor-market developments in the United States and other rich countries. Focusing on Commuting Zones (CZs) that approximate US local labor markets, we examine whether the CZs that are most exposed to rising trade penetration are also those most impacted by computerization. On the technology front, we follow Autor and Dorn (forthcoming) who use data on occupation mix by CZ and data on job tasks by occupation to measure the degree to which CZs are specialized in routine job activities well suited to computerization. On the trade front, we follow Autor, Dorn, and Hanson (forthcoming) in identifying trade shocks using cross-industry and cross-CZ variation in import competition stemming from China’s rapidly rising productivity and falling barriers to foreign trade and investment.<sup>2</sup>

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<sup>1</sup>The reasoning here is that tasks that follow explicit codifiable procedures (what Autor, Levy, and Murnane 2003 call “routine” tasks) are both well suited to automation because they can be computerized, and are well suited to offshoring because they can be performed at a distance without substantial loss of quality.

<sup>2</sup>While we focus on labor market exposure to computerization and goods trade, a number of papers consider the roles of both computerization and offshoring (e.g., Autor and Dorn forthcoming; Goos, Manning, and Salomons 2012; Firpo, Fortin, and Lemieux 2012; Oldenski 2012; Michaels, Natraj, and Van Reenen forthcoming).

**I. Measurement**

Our concept for local labor markets is Commuting Zones (CZs) developed by Tolbert and Sizer (1996), who use county-level data from the 1990 census data to create clusters of counties that are characterized by strong commuting ties within a cluster, and weak commuting ties across clusters. The 722 CZs in our analysis cover the entire mainland United States.

Following an extensive literature, we conceive of automation as taking the form of a decline in the cost of computerizing routine tasks, such as bookkeeping, clerical work, and repetitive production and monitoring activities, thereby potentially displacing the workers performing these tasks. To measure the degree to which CZs were historically specialized in these routine, codifiable job activities that were intrinsically amenable to computerization, we proceed in two steps. Using data from the *Dictionary of Occupational Titles* (1977), we create a summary measure of the routine task–intensity *RTI* of each occupation, calculated as:

$$(1) \quad RTI_k = \ln(T_{k,1980}^R) - \ln(T_{k,1980}^M) - \ln(T_{k,1980}^A),$$

where  $T_k^R$ ,  $T_k^M$ , and  $T_k^A$  are, respectively, the routine, manual, and abstract task inputs in each occupation  $k$  in 1980.<sup>3</sup> This measure is rising in the importance of routine tasks in each occupation and declining in the importance of manual and abstract tasks. To measure cross-market variation in employment in routine-intensive occupations, we classify as routine occupations those that fall in the top third of the employment-weighted distribution of the *RTI* measure in 1980. Using this classification, we then assign to each commuting zone a routine employment share measure ( $RSH_{jt}$ ) equal to the fraction of CZ employment at the start of a decade that falls in routine task–intensive occupations:

$$(2) \quad RSH_{jt} = \left( \sum_{k=1}^K L_{jkt} \cdot 1[RTI_k > RTI^{P66}] \right) \times \left( \sum_{k=1}^K L_{jkt} \right)^{-1}.$$

Here,  $L_{jkt}$  is the employment in occupation  $k$  in commuting zone  $j$  at time  $t$ , and  $1[\cdot]$  is the indicator function, which takes the value of one if the occupation is routine-intensive by our definition.

The rapid growth in US imports from low-income countries since the early 1990s is driven largely by China, whose transition to a market-oriented economy has yielded rapid rates of productivity growth arising from massive rural-to-urban migration, industries gaining access to long banned foreign technologies and inputs, and multinational enterprises being permitted to operate in the country (Naughton 2007). Compounding the effects of these internal reforms is China’s accession to the World Trade Organization (WTO) in 2001, which further expanded the country’s access to foreign markets.

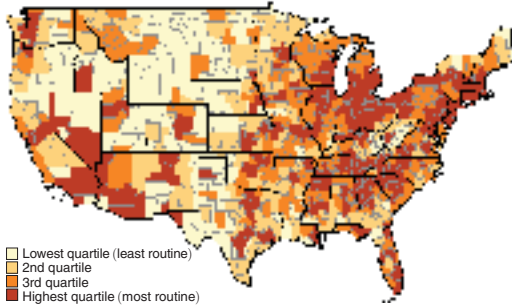
Following the empirical specification derived by Autor, Dorn, and Hanson (forthcoming), our main measure of local-labor-market exposure to import competition is the change in Chinese import exposure per worker in a CZ, where imports are apportioned to the CZ according to its share of national industry employment:

$$(3) \quad \Delta IPW_{uit} = \sum_j \frac{L_{ijt}}{L_{ujt}} \frac{\Delta M_{ucjt}}{L_{it}}.$$

In this expression,  $L_{it}$  is the start of period employment (year  $t$ ) in CZ  $i$  and  $\Delta M_{ucjt}$  is the observed change in US imports from China in industry  $j$  between the start and end of the period. The difference in  $\Delta IPW_{uit}$  across local labor markets stems entirely from variation in local industry employment structure at the start of period  $t$ . This variation arises from differential concentration of employment in manufacturing versus nonmanufacturing activities and specialization in import-intensive industries within local manufacturing. Differences in manufacturing employment shares are not the primary source of variation, however; in a bivariate regression, the start-of-period manufacturing employment share explains less than 25 percent of the variation in  $\Delta IPW_{uit}$ .

<sup>3</sup> Tasks are measured on a zero to ten scale. For the 5 percent of microdata observations with the lowest manual task score, we use the manual score of the fifth percentile. A corresponding adjustment is made for abstract scores.

Panel A. Routine Employment Share by Commuting Zone in 1990



Panel B. Trade Exposure by Commuting Zone, 1990–2007

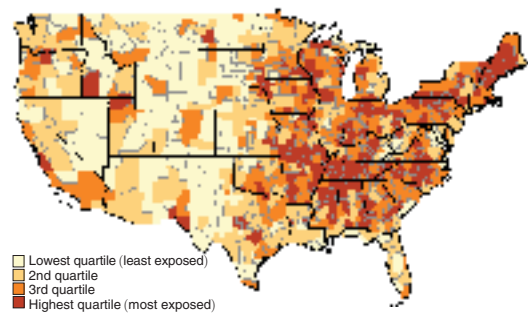


FIGURE 1. ROUTINE EMPLOYMENT AND TRADE EXPOSURE BY COMMUTING ZONE

## II. Results

Are the CZs that are most exposed to rising trade penetration also those most impacted by computerization? To explore this question, Figures 1 and 2 illustrate the geography of trade and technology exposure at the Commuting Zone level. Each panel of the figures presents a map of the 48 contiguous US states with all 722 CZ boundaries outlined in gray. In Figure 1, panel A, the interior of each CZ is shaded to indicate its quartile rank within the distribution of CZs in the fraction of workers that were employed in routine task-intensive occupations in 1990.<sup>4</sup> Darker colors correspond to higher quartiles of *RSH*, with the lightest color denoting CZs in the lowest quartile, and the darkest color denoting CZs in the fourth quartile.

Evident from this figure is that the CZs with the highest employment shares in routine task-intensive occupations constitute a mixture of manufacturing-intensive locations (e.g., Cleveland, Detroit, Milwaukee, and Minneapolis) and human capital-intensive population centers, such as New York, Chicago, Dallas, and Los Angeles. This pattern reflects the dual sources of routine task-intensive occupations: blue-collar production occupations associated with capital-intensive manufacturing; and white-collar office, clerical, and administrative support occupations associated

with banking, insurance, finance, and other information-intensive sectors.

Figure 1, panel B presents analogous information for exposure to import competition from China. In this panel, the lightest shading indicates CZs in the lowest quartile of trade exposure increase between 1990 and 2007 (measured as the change in real dollars of imports per worker), and the darkest color indicates CZs that are in the highest quartile of trade exposure increase. As expected, many manufacturing-intensive regions appear among the most trade-exposed CZs, including substantial parts of the Northeast and South Central United States, where labor-intensive goods manufacturing, such as furniture, rubber products, toys, apparel, footwear, and leather goods, is concentrated.

A comparison of the two panels of Figure 1 indicates both clear overlaps and pronounced differences among the sets of CZs with high trade exposure and those with high technology exposure. Most notable, however, is that trade exposure is geographically more concentrated. A substantial fraction of the top quartile of trade-exposed CZs are located in a small cluster of states, including Tennessee, Missouri, Arkansas, Mississippi, Alabama, Georgia, North Carolina, and Indiana. By contrast, routine task-intensive CZs are more dispersed throughout the United States.

Table 1 highlights the contrasting geography of trade and technology exposure by summarizing our two exposure measures for the eight major US census divisions that make up the contiguous US states. Growth in import exposure per worker differs by more than a factor of six across

<sup>4</sup> Rankings are unweighted, and, hence, each quartile contains roughly one-fourth of the 722 total CZs.

TABLE 1—TRADE AND TECHNOLOGY EXPOSURE BY CENSUS DIVISION

	I. Trade exposure	II. Tech exposure
	Growth imports per worker (\$1,000s)	% employees in routine occupations
East South Central	4.00	29.76
Mid-Atlantic	2.55	30.85
East North Central	2.37	31.31
New England	2.28	29.70
South Atlantic	2.15	29.80
West North Central	1.60	27.51
West South Central	1.56	27.39
Pacific	1.21	27.87
Mountain	0.62	26.51

*Notes:* The table shows unweighted averages of commuting zone technology and trade exposure within census divisions. Routine employment share is averaged over 1990 and 2000, and ten-year equivalent growth in imports per worker in real 2007 dollars (expressed in \$1,000) is averaged over 1990–2000 and 2000–2007.

census divisions, increasing, for example, by an average of 4,000 dollars per worker per decade in the East South Central division between 1990 and 2007 versus a relatively modest 620 dollars per worker per decade in the Mountain division. The geography of technology exposure is, by contrast, far less regionally concentrated; the most and least exposed regions differ by only a few percentage points in their share of employment in routine intensive occupations. This pattern does not, however, reflect a paucity of geographic variation in the *RSH*. Indeed, among CZs with populations exceeding 750,000, *RSH* varies by as much as 10 percentage points within the state of California alone.

Figure 2 facilitates a direct comparison of exposure to technology and trade by dividing CZs into three groups: those in the highest quartile of both trade and technology exposure; those in the lowest quartile of both trade and technology exposure; and the remainder. If trade and technology exposure were perfectly positively correlated across locations, one-fourth of CZs would be found in each of the first two groups. If instead they were uncorrelated, roughly 6 percent (one-sixteenth) of CZs would be in the high-high and low-low groups, with the remaining seven-ninths in the residual category. In reality, 9 percent of CZs are in the top quartile of both trade and technology exposure, and 14

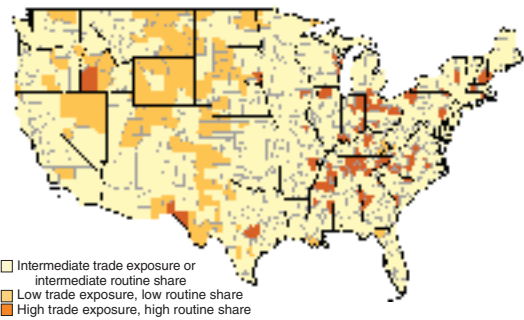


FIGURE 2. THE JOINT GEOGRAPHIC DISTRIBUTION OF TRADE AND TECHNOLOGY EXPOSURE

percent are in the bottom quartile of both trade and technology exposure. A simple population-weighted correlation between the trade and technology exposure variables finds that there is almost no relationship between the two: the correlation is  $-0.02$  for the 1990 to 2000 period and  $0.01$  for the 2000 to 2007 period.

Table 2 contrasts employment patterns among the full sample of CZs and the CZs that are in the top quartile of either technology or trade exposure. Highly trade-exposed and technology-exposed CZs are substantially above average in their manufacturing employment shares. However, these CZs differ substantially in their occupational composition. Most notably, technology-exposed CZs exceed the nationwide average of employment in “abstract” managerial and professional occupations and in “routine” clerical occupations, whereas trade-exposed CZs fall below the national average in both of these occupational categories. This pattern reflects the fact that CZs with high technology exposure are variously specialized in a mixture of manufacturing and information-intensive production activities (e.g., finance and insurance). By contrast, the US manufacturing industries that are most exposed to China trade, such as shoes, textiles, and furniture, are comparatively labor intensive and tend to employ few workers in abstract or in routine clerical occupations. In short, highly trade-exposed and highly technology-exposed CZs are dissimilar both from average CZs and from one another.

A summary answer to our question regarding the geography of trade and technology exposure is that the sets of heavily trade-exposed CZs and

TABLE 2—INDUSTRY AND OCCUPATION COMPOSITION OF COMMUTING ZONES WITH HIGH TECHNOLOGY OR TRADE EXPOSURE

	All CZ (1)	Top quartile technology exposure (2)	Top quartile trade exposure (3)
<i>Share of working age pop. employed in:</i>			
Manufacturing industry	11.8	16.2	17.5
Nonmanufacturing industry	56.6	55.3	50.9
Abstract occupation	20.3	23.1	19.0
Routine occupation, clerical	14.1	16.3	13.7
Routine occupation, production	7.9	9.9	11.3
Manual occupation	26.1	22.3	24.5

*Notes:* Column 1 shows unweighted statistics for the full sample of commuting zones. Columns 2 and 3 show corresponding statistics for the quarter of CZs with highest technology or trade exposure. “Abstract” occupations include managers, professionals, technicians, financial sales, and public security occupations. “Clerical routine” occupations include clerical and retail sales occupations, while “production routine” occupations include precision production and operator occupations. “Manual” occupations include service, transportation, repair, construction, and agricultural and mining occupations.

of heavily technology-exposed CZs are largely disjoint. This feature of the data facilitates the identification of the independent contributions of trade and technology to local labor-market outcomes. We do not interpret the absence of overlap in the geography of trade and technology shocks to mean that these two forces are unconnected. Multinational enterprises choosing how pervasively to automate production would naturally consider offshoring to low-wage countries as an alternative or even as a complementary strategy. At the regional level, however, the perceived consequences of trade and technology are likely to be distinct. The US local labor markets that have borne the brunt of import competition from China appear to be quite different from those most subject to the computerization of the workplace. These differences in exposure likely matter for regional adjustment to trade and technology shocks and may contribute to regional variation in changes in the structure of employment and wages.

### III. Conclusions

There is a wide agreement among economists that technological change and expanding international trade have led to changing skill demands and growing inequality or polarization of labor market outcomes in the United States and in other rich countries. This paper highlights important differences in the exposure of local labor markets to the impacts of technology and trade. Regional exposure to technological change, as measured by specialization in routine task-intensive production and clerical occupations, is largely uncorrelated with regional exposure to trade competition from China. While the impacts of technology are present throughout the United States, the impacts of trade tend to be more geographically concentrated, owing in part to the strong spatial agglomeration of labor-intensive manufacturing. Our findings suggest that it should be possible to separately identify the impacts of recent changes in trade and technology on US regional economies.

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