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ABSTRACT

The Effect of Trade on the Demand for Skill - Evidence from the Interstate Highway System*

Since changes in trade openness are typically confounded with other factors, it has been difficult to identify the labour market consequences of increased international trade. The advent of the United States Interstate Highway System provides a unique policy experiment, which I use to identify the effect of reducing trade barriers on the relative demand for skilled labour. The Interstate Highway System was designed to connect major metropolitan areas, to serve national defence and to connect the United States to Canada and Mexico. As a consequence – though not an objective – many rural counties were also connected to the highway system. I find that these counties experienced an increase in trade-related activities, such as trucking and retail sales, by 7-10 percentage points per capita. Most significantly, by increasing trade the highways raised the relative demand for skilled manufacturing workers in counties with a high endowment of human capital and reduced it elsewhere, consistent with the predictions of the Heckscher-Ohlin model.

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1 Introduction

The effect of reducing global trade barriers on inequality has been the subject of intense debate (Freeman 2004). In a two-factor H-O model with two economies, the removal of trade barriers favors high-skilled workers in the skill-abundant developed world and low-skilled workers in the less developed world. But recent work challenges the applicability of the H-O framework for the analysis of the labor market consequences of trade.[1] We therefore have no consensus regarding the effect of trade on the relative demand for skilled labor.

The principal empirical challenge in assessing the general-equilibrium effect of international trade on labor demand is identification. Recent work estimates the effects of trade liberalization (Attanasio, Goldberg, and Pavcnik 2003) and exchange rate shocks (Verhoogen 2004) on labor demand in developing countries. While these case-studies are informative, they may be insufficient to determine the effect of removing trade barriers on the demand for skill. First, the consequences of trade liberalization depend on the distribution of industrial protection, while exchange rate shocks affect exporters and importers in opposite ways. Second, governments that liberalize trade or face rapid currency devaluation may affect labor markets directly. Finally, concurrent pervasive skill-biased technical change may also change the demand for skill. Taking a different approach, Borjas, Freeman, and Katz (1997) use factor-content analysis to estimate the effect of trade on wages. But as Panagariya (2000) shows, these calculations rely on a fairly restrictive set of assumptions. To better understand the effect of trade on the demand for skill, we require exogenous variation in trade barriers that affects a wide range of industries and allows us to control for other concurrent changes in the labor market equilibrium.

In this paper, I use the advent of the United States Interstate Highway System as an interesting policy experiment to estimate the effect of reducing trade barriers on the demand

[1] The H-O model cannot fully explain recent changes in worldwide labor demand (Krugman 1995; and Berman, Bound, and Machin 1998). Against this backdrop, theoretical work suggests that reduced trade barriers may increase the demand for skilled labor even in economies with a low skill endowment (Feenstra and Hanson 1996; Acemoglu 2003; Kremer and Maskin 2003; Matsuyama 2004; and Antras, Garicano, and Rossi-Hansberg 2005).

for skill. The construction of the Interstate Highway System began after funding was approved in 1956, and by 1975 the system was mostly complete, spanning over 40,000 miles. The highways were designed to address three policy goals. First, they were intended to improve the connection between major metropolitan areas in the United States. Second, they were planned to serve U.S. national defense. And finally, they were designed to connect with major routes in Canada and Mexico. As a consequence – but not an objective – many rural counties were also connected to the Interstate Highway System.[2] Rural counties crossed by the highways experienced an exogenous reduction in barriers to trade, providing an opportunity to examine how product market integration affects relative factor demand.[3]

I show that large trucks used the rural Interstate Highways much more intensively than other types of vehicles. As the highway construction was being completed, the trucking industry grew very rapidly and trucks became the primary mode for cross-county commerce. I find that highways increased trucking income and retail sales by about 7-10 percent per capita in rural counties they crossed, relative to other rural counties. This suggests that highway counties took advantage of the reduction in trade barriers to increase their trade with other counties.

I interpret the changes in highway counties, relative to non-highway counties, as the mean effect of reduced trade barriers. I interact this variation with pre-existing differences in human capital endowment between the rural counties, as proxied by the fraction of high school graduates among persons 25 years and older in 1950. I find that on average highways did not change the wage-bill of (high-skilled) non-production workers relative to the wage-bill of (low-skilled) production workers in manufacturing.[4] But in rural counties that had a highly educated workforce, highways increased the relative wage-bill of non-production

[2] An extensive literature, dating back to Fogel (1964) examines the effects of transportation infrastructure on growth. Of this literature, my approach is closest to Chandra and Thompson (2000), who estimate the effects of the Interstate Highway System on growth in rural counties.

[3] Horiba and Kirkpatrick (1981), Davis et al. (1997) and others use within-country variation in factor endowments to test various predictions of the Heckscher-Ohlin framework. But this literature has not identified exogenous variations in regional factor endowments or in trade barriers.

[4] I focus on manufacturing due to the availability of wage and employment data.

workers, and where the workforce was less educated, highways decreased the relative wage-bill of non-production workers. These results are robust to the inclusion of time-varying controls for geographic location and land abundance. This finding is consistent with the H-O prediction that trade increases the demand for skill where it is relatively abundant and decreases it elsewhere.

Using my estimates I calculate the elasticity of the wage-bill of non-production workers relative to production workers in manufacturing with respect to the ratio of domestic trade to local GDP. In a county that exceeds the mean level of education by one standard deviation this elasticity is roughly equal to 1. This finding suggests that trade may contribute to changes in labor market inequality, but its effects are not very large.[5]

Another prediction of the H-O model is that trade shifts employment towards industries intensive in the relatively abundant factor. To test this prediction, I calculate a measure of skill intensity of the manufacturing workforce in each county using data on 2-digit Standard Industrial Classification (SIC) industries. I find that highways did not significantly shift employment to skill-intensive manufacturing industries in skill-abundant counties, nor did it shift employment to low-skill industries where skill was scarce. This finding suggests that compositional changes may have taken place within industries or product classes.[6] Alternatively, it is possibile that trade has increased the demand for skilled workers in skill-abundant counties through other channels.

My interpretation that highways affect county-level outcomes by removing trade barriers faces several potential challenges. First, political agents may have changed highway routes in response to economic or demographic conditions in rural counties, contrary to the original planners' intent. In order to address this concern, I instrument for highway location using the original plan of routes proposed in 1944. I also construct a second instrument, based on the fact that an Interstate Highway is more likely to run through a rural county that lies to the north, south, east, or west of the nearest major city. Estimates using these instrumental

[5] However, it is possible that removing trade barriers across countries may have other effects on inequality.
[6] Schott (2004) shows evidence of specialization within product classes in international trade.

variables (IV) are consistent with the ordinary least squares (OLS) estimates. In addition, I find that measures of trade and demand for skill do not differ significantly between highway and non-highway counties before highway construction was completed. Second, my empirical strategy assumes that counties approximate separate labor markets. This assumption is consistent with the finding of many recent studies that wage differences vary persistently across regional markets in the United States.[7] In the sample I use, about three-quarters of the workers are employed in their county of residence, suggesting that counties are plausible units for the analysis of local labor markets. My results also suggest that the effect of highways on the relative wage and relative employment of high skilled workers were the same in sign. This finding is consistent with a change in the relative demand for skill, as we would expect from opening to trade, so the effect on the relative wage bill is unlikely driven purely by migration. Finally, one might argue that highways could have affected patterns of commuting, changing the geographic skill distribution of employment. However, I find that highways had little effect on passenger car traffic, and that the fraction of workers who commute to work did not increase in highway counties relative to other counties.

Section 2 describes a simple theoretical framework, which considers the effects of trade on the relative demand for skilled workers. Section 3 presents a brief historical overview of the planning and construction of the Interstate Highway System. Section 4 discusses the data and the samples I use. Section 5 discusses the effects of highways on trade. Section 6 estimates the effect of highways on the relative demand for skilled workers, and Section 7 reports estimates of their effect on the industrial composition of employment. Section 8 presents conclusions.

2 Theoretical Framework

To frame the key questions of this investigation, it is useful to first discuss the theoretical implications of reducing trade barriers on the demand for skill. I begin by discussing the

[7] See for example Acemoglu, Autor and Lyle (2004); Bernard, Redding and Schott (2005); and Card and DiNardo (2001).

predictions of a Heckscher-Ohlin model, and then consider alternative models that predict an effect of trade on the demand for skill.

In a two-factor Heckscher-Ohlin model with two economies and a continuum of goods, patterns of trade are determined by differences in factor endowments (see Appendix A). Focusing on high-skilled and low-skilled workers as the factors of interest, the model predicts that a skill-abundant economy has a comparative advantage in skill-intensive goods, so the skill content of its exports is higher than the skill content of its imports.

This model has several testable implications. First, opening to trade increases the relative wage of the locally abundant factor; this may lead to factor price equalization, unless factor endowments are very different. Since the model assumes factor immobility (see discussion below), this prediction implies that trade increases the relative wage bill of the abundant factor in each economy. Second, trade shifts production to industries intensive in the locally abundant factor. If factor prices are not equalized, each economy specializes in goods intensive in the locally abundant factor. Finally, the model predicts that each industry becomes relatively more intensive in the locally scarce good. Unfortunately, due to data limitations I am unable to examine this last prediction of the model.

The predictions outlined above are robust to allowing free migration of workers between the two economies (see Appendix B). Suppose each economy has a fixed supply of housing and people spend a constant fraction of their income on housing. Assume for example that skilled workers prefer to live in the home economy.[8] If migration is possible but trade is too costly, the home economy is more skill-abundant, and therefore has a lower skill premium and higher price of housing. Opening to trade increases the demand for skilled labor in the home economy, raising the relative wage-bill share of skilled workers through inflows of high-skilled workers and outflows of low-skilled workers.

The two-factor model may be extended to include capital, and its predictions hold as

[8] If workers do not prefer either economy and migration is costless then the skill endowments of both economies are identical (assuming both are populated). The assumption of different preferences yields differences in endowment and motivates trade.

long as free flow of capital equalizes the interest rate. Including land as another factor of production can change the model's predictions, so in the following sections I test whether controlling for differences in land abundance affects the outcomes of interest.

Trade may also affect the demand for skill in other ways, and recent work suggests that opening to trade may increase the demand for skill everywhere. Feenstra and Hanson (1996) suggest that trade allows goods that require an intermediate level of skill to be outsourced from high-skilled economies to low-skilled economies, raising the demand for skill in both. Matsuyama (2006) argues that in an international setting exporting is more skill-intensive than selling on the local market, so reducing trade barriers could favor skilled workers everywhere. If a similar mechanism applies in the domestic U.S. setting, trade may increase the demand for skilled workers even where skill is scarce. A similar result may occur if the assumption of identical and homothetic preferences is violated. For example, Leonardi (2003) argues that wealthier and more educated workers tend to consume more skill-intensive goods, so if trade increases income it could favor skilled workers.

In order to test the effect of an exogenous reduction in trade barriers on the demand for skilled labor, consider two potential trading blocs. Each bloc consists of two economies, one of which is more skill-abundant. To make the link with the empirical work in the next section, I now propose to think of the economies in each trading bloc as counties. Initially, the counties in each bloc are autarkic, and relative wages are determined by local supply and demand. Highways are then constructed between the economies of one bloc, allowing them to trade. Thus we expect that highways increase trade flows between those counties, and I can thanexamine the effect of opening to trade on the dmand for skilled labor and the industry composition. But before testing these predictions, I trace the origins of the interstate highways and study their role in reducing trade barriers.

3 History of the Interstate Highway System

The Interstate Highway System provides a natural experiment that I envision as inducing an exogenous reduction in trade barriers. During the first half of the 20th century much of the economic activity in the United States was highly localized, as distances were long and transcontinental travel was slow. Lewis (1997) describes President Franklin Delano Roosevelt's early interest in constructing a national network of highways to reduce travel time:

> Given his interest in road building, it is little wonder that early in 1937 [President] Roosevelt called Thomas MacDonald, chief of the Bureau of Public Roads, to the White House. On a map of the United States, the president had drawn three lines north and south and three lines east and west. These would be the routes for a new transcontinental system of interstate toll highways, he explained.

This grid pattern persisted in all the subsequent modifications of the highway plan; the next section describes how I use it to construct an instrument for the highway system.

The Federal-Aid Highway Act of 1944 laid out a plan for a system of highways designed "To connect by routes as direct as practicable the principal metropolitan areas, cities and industrial centers, to serve the national defense and to connect suitable border points with routes of continental importance in the Dominion of Canada and the Republic of Mexico."[9] Although rural areas were not considered by the planners, highways were designed to cross many rural counties as an unintended consequence of meeting these policy goals.

The construction of the Interstate Highway System began following the approval of the Federal-Aid Highway Act of 1956, which also changed planned routes of the highways.[10] The legislation stipulated that access to the highways be free, except for a few existing toll

[9] Public Roads Administration press release (1947). Figure 2 shows the layout of the plan.

[10] In subsequent years further changes were made to the design of the system, but they were relatively minor.

highways incorporated into the Interstate Highway System. The federal government bore 90 percent of the cost of construction, while the states financed the remaining 10 percent. Figure 3 shows that in 1966 the highways were still mostly disconnected–thick lines show constructed sections, while thin lines show planned sections. By 1975, however, almost all the sections had been completed (see Figure 4).

4 Data and Samples

I use a number of data sources to construct the sample of Interstate Highways. First, the National Transportation Atlas Databases (2002) identifies the exact routes of the highways. Second, I use historical data to restrict the sample to highways that were mostly constructed from 1959-1975. I exclude state-interstate highway cells for which the 1975 mileage was less than 80 percent of the 2002 mileage.[11] Using maps issued by the Bureau of Public Roads and the Federal Highway Administration, I exclude state-interstate highway cells where the 1959 mileage exceeded 20 percent of the 1975 mileage. This selection criterion excludes toll highways, which were constructed before 1959 and later incorporated into the Interstate Highway System. Third, I restrict the sample to longer highways, which more likely connect distant locations (as envisioned by the early planners), and are therefore less affected by local economic conditions. I therefore exclude all 3-digit highways, which serve metropolitan areas, and restrict the sample to highways whose total remaining length exceeds 500 miles. This leaves most segments of 18 highways, half of which run primarily north and south and half of which run primarily east and west. Together these segments extend over more than 24,000 miles, more than half of the total length of the Interstate Highway System.

The Interstate Highways were constructed in all 48 contiguous states, but they only crossed some counties, affording substantial within-state variation. Counties are a meaningful geographic unit for the analysis of labor markets, since from 1970-1990 only about 20-30 percent of workers in rural counties commuted to work outside their county of residence.

[11] To determine the length of each highway in December 1975 in every state, I use the Interstate Gap Study (1976); this study is a report to Congress by the Department of Transportation.

Publicly available micro data do not identify individuals' county of residence, so I use aggregate county-level data from various sources. First, County and City Data Books provide data on earnings and employment of production and non-production workers in manufacturing, retail sales, schooling, and population. Second, Bureau of Economic Analysis Regional Economic Accounts give data on earnings in trucking and warehousing. Third, County Business Patterns present information on the industrial composition of manufacturing. Finally, the National Transportation Atlas Database allows me to ascertain the geographic location of counties and cities. I limit the sample to counties whose population in 1950 was more than 50 percent rural and whose land area changed by no more than 5 percent from 1950-1980. I also exclude counties that had one or more highway segments running through them, but no segment was constructed between 1959-1975.

Table 1 shows descriptive statistics for the sample of counties. Sample counties were predominantly rural in 1950, so they were more sparsely populated and somewhat poorer than non-sample counties. About three-quarters of the mileage was planned for construction on new right-of-way, most likely due to the high cost of land adjacent to existing highways. This suggests that highway counties may have been negatively selected compared to non-highway counties. But Table 1 shows that highway counties were somewhat richer and experienced faster population growth even before the construction of the highways. These differential rates of population growth motivate an analysis that compares counties in per capita terms and examines the possibility of pre-existing trends in key variables.

Although the Interstate Highways were not intended to serve rural counties, their routes may have been changed by political considerations correlated with the economic conditions that prevailed after World War II. I therefore use an indicator for having a highway planned in 1944 (z_{1c}) as an instrument for the location of the interstate highway system.[12]

I use the geographic variation in the allocation of highways to counties to generate a

[12] In concurrent and independent research, Baum-Snow (2004) looks at the effect of highways on population growth in suburban areas. He uses a 1947 map of the Interstate Highway System to construct an instrument for the routes of highways in metropolitan areas. Lahr et al. (2005) also examine the effect of highways on the size of metropolitan areas.

second instrument. Figure 5 shows a key feature of the Interstate Highway System, dating back to President Roosevelt: routes are mostly along lines of latitude and longitude. Since highways were also planned to connect cities, I calculate the orientation of the nearest large city with respect to each county's geographic centroid:[13]

$$A_c = \frac{90}{(\pi/2)} \arcsin\left((\widetilde{y}_c - y_c) / \sqrt{(\widetilde{x}_c - x_c)^2 + (\widetilde{y}_c - y_c)^2} \right), \tag{1}$$

where (x_c, y_c) and $(\widetilde{x}_c, \widetilde{y}_c)$ are the coordinates of the county centroid and the nearest city. I use this measure to construct an instrument for the probability that a county received a highway: $z_{2c} = \frac{|45-|A_c||}{45}$.

Figure 6 plots a kernel regression of the probability that a highway crosses a county as a function of the orientation. If you live in a rural county and the nearest major city is to your north, east, or west, the odds of having an interstate run through your county are much better than if the city's orientation if off one of the major axes.

To test if the two instruments affect the probability that a highway crosses a county, I estimate the following cross-section regressions of the form:

$$h_c = \alpha z_c + \beta x_c + \varepsilon_c, \tag{2}$$

where h_c is an indicator for a segment of the Interstate Highway System crossing county c, z_c includes either (or both) instruments z_{1c}, z_{2c}, and ε_c is a residual. The county level controls, x_c, vary across specifications, and include region fixed effects and the distance from the county centroid to the nearest city. Table 2 shows that the instrument based on the 1944 plan is a very strong predictor of the routes along which highways were eventually constructed. The instrument based on the direction to the nearest city also has substantial

[13] The sample of cities is constructed using 1950 population data. It includes the most populous city in each state and any city that had at least 100,000 persons. The resulting sample includes 119 cities. I calculated the geographic centroid of each county using the Geographic Information System.

predictive power for the location of highways.[14]

5 The Effect of Highways on Trade

In this section I estimate the effect of the Interstate Highway System on domestic trade. By allowing traffic to flow more rapidly, the highways reduced barriers to domestic trade, facilitating cross-county commerce. Since I have no data on county level imports and exports to the rest of the nation, I measure correlates of domestic commerce - trucking and retail sales. I find that trucks used rural highways very intensively, and aggregate data suggests that the Interstate Highway System contributed to the growth of the trucking industry. Next, I show that highway counties experienced a large increase in trucking and retail sales relative to other counties after the Interstate Highway System was completed. While highways appear to have affected trade, I show that cross-county commuting did not change differentially for highway counties relative to other counties. Finally, I discuss the implications of highways for the equalization of prices and wages.

The Interstate Highway System consists almost entirely of four-lane, divided highways with controlled and limited access. As such, it allows vehicles to travel more safely and at higher speeds in rural areas. Data from 1982-1991 suggests that the average speed of vehicles on rural Interstate Highways was at least 6-9 percent higher than the average speed on other rural principal and minor arterials and 10-15 percent higher than the average speed on rural major collectors.[15] In addition, rural Interstate Highways allow traffic to bypass small urban areas, allowing even larger time gains. Since the late 1970s, rural Interstate Highways have carried about 8 percent of the total passenger car traffic and 11 percent of single-unit truck traffic in the U.S. In contrast, rural Interstate Highways have borne over 30 percent of the total traffic of combination trucks, which are typically designed to transport

[14] I later use the instruments to test if outcomes change differentially over time for highway and non-highway counties. For that purpose I interact each instrument with a dummy for post-1975, and use this interaction term to instrument for the interaction of the highway dummy with post-1975. The first stage for the interacted regression is essentially identical to the results in Table 2.

[15] The data are from the National Transportation Statistics 1993, Table 13.

large volumes over long distances (Table 3).[16] In fact, in the past couple of decades trucks account for almost one-fifth of the traffic on rural Interstate Highways. It thus appears that the Interstate Highway System has proved very important for the trucking industry.

During the 1970s, as the Interstate Highway System opened for traffic, the use of combination trucks expanded much more rapidly than in previous or subsequent decades (see Figure 7).[17] In 1969, the ratio of earnings in the trucking and warehousing industry over earnings in the railroad industry was about 1.7; by 1997 this ratio increased to almost 4.8 (Regional Economic Accounts 2004). By then trucks transported more than 71 percent of the value of domestic trade in the United States.[18] Thus, the aggregate evidence suggests that the Interstate Highway System facilitated domestic trade by allowing a more extensive use of trucks.

My interpretation of the effect of the Interstate Highway System on economic outcomes assumes that they reduced barriers to trade across counties. In 1997 most of the domestic trade in the U.S. – about 58 percent – was conducted across state borders; this is clearly a very low bound on cross-county trade. In fact, almost two-thirds of the value of commodities transported by truck were shipped for at least 50 miles and therefore, most likely, across county borders.[19] These figures are consistent with the view that the highways are important for cross-county trade.

The evidence presented thus far pertains to aggregate trends, but we can also examine the effect of highways on rural counties they crossed, relative to other rural counties. I have no county-level measure of real trucking activity, such as miles traveled or value of goods transported. The Bureau of Economic Analysis does, however, provide county-level data on

[16] A combination truck consists of a truck tractor and at least one trailer unit.

[17] Federal regulations that govern the weight and dimensions of trucks and other motor vehicles were first enacted in the Federal-Aid Highway Act of 1956. They were subsequently revised in 1975 and 1983 (U.S. House of Representatives, 2002). It is therefore highly unlikely that the increased use of combination trucks in the first half of the 1970's was caused by such regulation.

[18] Commodity Flow Survey (1997). If we include commodities transported by multiple modes of transportation these figures are even higher.

[19] If we the median county in the sample were a square, it would measure about 25 miles on a side. The maximum linear distance to traverse within such a square is about 35 miles.

earnings in the trucking and warehousing industry. I use this data to estimate specifications of the form:

$$T_{ct} = \psi_c + \rho_t + \alpha_t h_c + \varepsilon_{ct}, \tag{3}$$

where T_{ct} is log earnings in the trucking and warehousing industries per capita in county c at time t; ψ_c and ρ_t are county fixed effects and year effects; α_t is a time-varying coefficient on the indicator for highway counties, h_c; and ε_{ct} is a residual. Recall from Table 1 that highway counties are on average closer to large cities. To check that the estimates are not driven by differential trends for counties with different locations or land-abundance, some specifications control for time-varying effects of region, distance from the county centroid to the nearest city, and 1950 population density.

The results (Table 4 and Figure 8) indicate that earnings in the trucking and warehousing industry, per capita, increased in highway counties relative to non-highway counties. Most of the increase took place during the 1970s, consistent with the timing of the construction of the Interstate Highway System. It is possible that non-highway counties also benefitted from the highways, although to a lesser extent. Conversely, some trucking activity may have shifted from non-highway counties to highway counties. Thus we can only identify the differential effect of highways on highway counties relative to non-highway counties.[20]

The results in Table 4 suggest that highways indeed facilitated the flow of commodities. However, these findings do not rule out the possibility that truckers reside in highway counties and transfer goods used in other counties. To further substantiate the hypothesis that highways increased the flow of commerce in counties they crossed, I estimate their effect on retail sales. Specifically, I regress log retail sales per capita on the same regressors as in (3); similar specifications control for other covariates. The results (Table 5 and Figure 8) show that highway counties experienced a rapid increase in retail sales relative to non-highway counties since the 1970s. The results also indicate that highway and non-highway counties displayed similar trends before and during the highway construction. Given that highways

[20] The available data also does not account for trucks used by firms outside the trucking industry.

also increased trucking, it appears very likely that the increase in retail sales is due to goods "imported" from outside the county.[21]

In order to address the concern that the results may be affected by selection, I also estimate the effect of highways on trucking and retail sales using the instrumental variables described in the previous section. Table 6 presents estimates using specification of the form:

$$Y_{ct} = \psi_c + \rho_t + \beta d_{1975} h_c + \varepsilon_{ct}, \tag{4}$$

where Y_{ct} is the outcome and d_{1975} is an indicator for post-1975, when the highway segments in the sample were mostly complete. Another specification substitutes a state-level index of highway completion for the post-1975 indicator.[22] Finally, I also estimate this equation using IV, where $z_{c,1}d_{1975}$ or $z_{c,2}d_{1975}$ serve as instruments for $h_c d_{1975}$.

OLS estimates suggest that highways increased retail sales per capita by 8-10 percentage points and IV estimates using the 1944 plan give a similar result. Using the direction instrument, rather than the 1944 plan, gives estimates that are larger and less precise. When I limit the sample to the Midwest and South, where the first stage is larger, the IV estimates are twice as large as the OLS estimates and marginally significant. The OLS estimates for earnings in trucking and warehousing per capita also increased by about 8-10 percentage points. The IV estimates are less precise, but they are similar to the OLS estimates. These results are consistent with the view that highways affected economic outcomes by changing the patterns of trade.

[21] Highways could increase retail sales per capita for a number of reasons. First, H-O theory predicts that trade will increase income, thereby raising average consumption (see Dornbusch, Fischer, and Samuelson 1980). Second, if highways facilitate market integration of rural areas, sales may shift to formal establishments, further raising sales of retailers. Finally, it is possible that retailers will make capital investments complementary to the highways, further increasing their sales.

[22] The benchmark specification assumes that highways affected outcomes only after 1975, when they were essentially complete. In order to relax this assumption, I calculate a state-level index of highway completion using the length of rural interstate highways with four lanes and restricted access control that were open to traffic. Since most of the interstate highways that were open to traffic in 1960 were toll roads incorporated into the system, I exclude them from my analysis. Thus, the state-level index measures if the mileage of highways in a given year, net of the 1960 mileage, accounts for more than 90 percent of the difference between the 1975 mileage and the 1960 mileage.

In the following analysis, I interpret the effect of highways on the labor market as a consequence of the removal of trade barriers. One potential concern about this interpretation is that highways may also affect patterns of commuting, thereby changing the geographic skill distribution of employment. Figure 7, however, suggests that rural Interstate Highways had little aggregate effect on passenger traffic. The final outcome in Table 6 is the fraction of workers, who commute to work outside their county of residence. The results show that commuting did not significantly increase in rural highway counties, compared to other rural counties.

A related concern is that migration patterns may be correlated with highway location for reasons other than a change in labor demand. My estimates suggest that highway counties experienced a faster rate of population growth both before and after the highways were constructed, with no evidence of a change in trend (results not shown). In the next section I discuss the possibility that highways changed the relative supply of skill, rather than the relative demand.

The theoretical framework also predicts that where costless trade is possible, commodity prices (though not necessarily factor prices) will be equal. The Interstate Highway System appears to have significantly reduced the cost of trade in commodities. While I have no direct evidence on price changes in rural areas, Parsley and Wei (1996) use data from 1975-1992 and find rapid convergence of commodity prices across U.S. cities. This finding is consistent with the theory, since all major U.S. cities are connected to the Interstate Highway System. Bernard, Redding, and Schott (2005) find that wage differences persist across geographically disparate labor markets in the U.S.; this suggests that factor endowment differences may have prevented factor price equalization.

6 The Effect of Highways on the Relative Demand for Skilled Labor

This section examines the effect of opening to trade on the relative demand for skilled labor. The H-O model predicts that by facilitating trade, highways increase the relative wage-bill of non-production workers in counties with a highly skilled workforce and decrease it in counties with a less educated workforce.[23] To test this prediction I interact the exogenous reduction in the cost of trade caused by the Interstate Highway System with pre-existing differences in human capital endowment. As explained in Section 4, there are no micro data that identify individuals' county of residence during the relevant time period. I therefore use the fraction of high school educated workers among persons 25 years and older in 1950, before the Interstate Highway System was constructed, as a measure of a county's skill endowment.[24] I use non-production and production workers in manufacturing as proxies for high- and low-skilled labor, respectively.[25]

In order to examine this prediction I estimate a regression of the form:

$$\ln\left(S_{ct}^{H}\right) = \psi_c + \rho_t + \beta d_{1975} h_c + \gamma d_{1975} h_c s_{c,1950} + \delta d_{1975} s_{c,1950} + \varepsilon_{ct}, \tag{5}$$

where $\ln\left(S_{ct}^{H}\right) = \ln\left(\omega_{ct}^{H} h_{ct}\right) = \ln\left(w_{ct}^{H}/w_{ct}^{L}\right) - \ln\left(H_{ct}/L_{ct}\right)$ denotes the wage-bill of non-production workers in manufacturing, relative to production workers. The fraction of high school graduates among persons 25 years and older in 1950 is $s_{c,1950}$, and d_{1975} is a dummy for post-1975.[26] Other specifications include county-level covariates, and IV estimates using $z_{1,c}$ and $z_{2,c}$, interacted with appropriate terms, to instrument for terms that include the highway dummy, h_c.

[23] As Table 1 shows, the sample counties are on average less skill abundant than the rest of the US. However, there is considerable variation in the sample counties' skill endowment, and about a quarter of the sample of counties had a higher fraction of high-school graduates than the US average in 1950.

[24] Using 1960 schooling data gives similar results.

[25] Census data for 1960 and 1980 indicate that non-production workers in manufacturing industries had about 2-3 more years of education than production workers. For further discussion of the differences between production and non-production workers see Berman, Bound and Griliches (1994).

[26] These regressions are weighted by 1950 population, since data for low population counties are less precise.

The first column of Panel A in Table 7 presents estimates of this equation under the constraint that $\gamma = \delta = 0$. The results show that on average, highways did not increase the relative demand for skill. Subsequent columns relax this constraint, and test the prediction that $\beta < 0$ and $\gamma > 0$. These results do suggest that highways significantly increased the relative demand for non-production workers in counties that had a highly skilled labor force and reduced it elsewhere. The results are robust to controlling for the contemporaneous fraction of high school graduates in the labor force and for time-varying coefficients on region dummies, distance from the county to the nearest city, and 1950 population density. The IV estimates using the 1944 plan are somewhat larger estimates than the OLS estimates, while the direction instrument is not precise enough to identify the effect of highways on labor demand.[27]

The results in Panels B and C of Table 7 suggest that highways increased both the relative wages and the employment share of non-production workers in high-skill counties, although most estimates are not precise. Similarly, highways appear to have reduced the wages and employment of non-production workers where skill was relatively scarce. These results are consistent with the H-O view, that trade shifts the relative demand curve for skilled labor. The change in wages and employment shares may reflect a movement along the relative supply curve for skilled workers. The positive and finite elasticity of the relative supply of skill may reflect endogenous cross-county migration as well as changes that took place within counties, such as occupational transition and entry or exit of workers from the market.

I use the results in Table 7 to evaluate the possibility that the effect of highways on the

[27] To test the hypothesis that the effect of highways on the relative wage-bill of skilled manufacturing workers varies by land endowment I add the interaction (1950 population density)*(post 1975)* highway to the specification in Table 7, panel A, column 3. This changes beta from -0.168 (0.068) to -0.177 (0.070) and gamma from 0.609 (0.241) to 0.605 (0.244), suggesting that land endowment has little effect on the outcome of interest. Taking the same baseline specification and controlling for a county-level index of skill intensity in manufacturing in 1967 (described in the Appendix) interacted with year dummies yields estimates of -0.153 (0.074) and 0.462 (0.253) for beta and gamma, indicating that these results are also not driven by differential time effects on counties with different industry compositions.

The results are also robust when I restrict the sample to counties that are farther than 50km from the nearest city.

wage-bill are due to changes in relative supply correlated with highway location, rather than a change in relative demand. Assume that the aggregate elasticity of substitution between high- and low-skilled workers is locally a constant, η, then the elasticity of the relative wage-bill of skilled workers with respect to their wages is:

$$\frac{\partial \ln \left(w_{ct}^H / w_{ct}^L \right)}{\partial \left[\ln \left(H_{ct} / L_{ct} \right) \right]} = -\frac{1}{\eta}. \tag{6}$$

There is a consensus in the literature that η is higher than 1 (e.g. Freeman 1986; Katz and Murphy 1992; and the elasticity implied in Angrist 1995). Using these estimates, the effect of highways (and highways interacted with 1950 schooling) on relative employment should have been bigger in magnitude than their effect on relative wages, and opposite in sign. Thus, the estimates in Table 7 suggest that highways changed the relative demand for skill, rather than the relative supply of skill.

As a further check, I test if highway counties experienced changes in the wage-bill of non-production workers, relative to production workers, before the highways were completed or after they were already in place. By time-differencing (5) (post-1975 minus pre-1975) we get an expression for the change in the relative wage-bill of non-production workers:

$$\Delta \ln \left(S_c^H \right) = \rho + \beta h_c + \gamma h_c s_{c,1950} + \delta s_{c,1950} + \varepsilon_c. \tag{7}$$

I estimate this equation using OLS (with and without county-level controls) and IV, instrumenting h_c and $h_c s_{c,1950}$ using $z_{i,c}$ and $z_{i,c} s_{c,1950}$, where $i = 1, 2$. Since data is not available for all counties and all years, I restrict myself to a constant sample of counties, for which I have data in 1947, 1967, 1982, and 1992. The results (Table 8) show that before the construction of highways was complete (1947-1967) the changes in the relative demand for skill did not vary significantly between highway and non-highway counties. This is true for both the OLS estimates (with and without county-level controls) and the IV estimates using the 1944 plan. As before, the direction instrument is not powerful enough to give precise results. The estimates for 1967-1982 are similar in magnitude to those found in Table 7. The estimate of the main effect of highways, γ, is statistically significant only in the IV estimate, while the estimate of δ is significant in all specifications. Finally, the changes that took place from 1982-1992 do not vary significantly across highway and non-highway counties. These results lend support to the hypothesis the Interstate Highway System was indeed the cause of the changes in the relative demand for skilled labor.

In order to assess the magnitude of the effect of trade I compare my estimates to those of Borjas, Freeman and Katz (1997). Borjas et al. use a factor-content approach to measuring the effect of trade on wage inequality. They find that imports to the U.S. from less-developed countries as a fraction of GDP increased by about 1.6 percentage points from 1980-1995. Using factor-content analysis they calculate that this increase could have raised the skill premium by about $0.9 - 1$ percentage points.[28] This suggests that the elasticity of the skill premium with respect to (Imports/GDP) was about 0.6.

Using my estimates for trucking (Table 4) I assume that highways increased trade by about 7 percentage points in counties they crossed, relative to other counties. Data from the commodity flow survey of 1997 suggests that value of goods traded domestically in the U.S. was roughly equal to the GDP. I assume that during the 1970s the ratio of domestic trade to GDP was about 0.9. This suggests that the change in (domestic trade/local GDP) induced in highway counties, relative to other counties, was about 0.063. In 1950, the fraction of high school graduates in the mean county in the sample was 0.251 with a standard deviation of 0.103. The OLS estimate of the effect of highways on the relative wage-bill of high-skilled workers (Table 7 Panel A, column 2) in a county that is one standard deviation above the mean level of education is 0.072 (p-value 0.03). The IV estimate (Table 7 Panel A, column 6) is 0.061 (p-value 0.12). This suggests that the elasticity of the relative wage-bill with respect to (domestic trade/local GDP) for a county that is one standard deviation above the mean

[28] This figure reflects the change in wages of college graduates relative to high-school graduates and of high-school graduates compared to high-school dropouts.

level of education is close to 1.[29] The estimates of the skill premium are somewhat smaller in magnitude and less precise.

The assumptions used in this paper are quite different from those used in the factor-content analysis of Borjas et al. (1997).[30] However, despite the differences in assumptions and sources of variation, the magnitude of our estimates appears quite comparable. My results therefore support the view that while trade may contribute to changes in labor market inequality, its effects are limited in magnitude.

7 The Effect of Highways on the Industrial Composition

The H-O framework also predicts that trade changes the industry composition of employment. Specifically, it predicts that trade causes a skill-abundant economy to shift its production towards more skill-intensive goods and vice versa for an economy where skill is scarce. In order to test this prediction I construct a measure of the skill intensity of each industry. I match the two-digit SIC codes to the 1950 classification of manufacturing industries in the household census and compute the fraction of non-production workers each industry's labor force. Using the County Business Patterns data I compute an index of the skill intensity of the manufacturing workforce: $I_{ct} = \sum_i n_{i,1960} I_{ict}$, where $n_{i,1960}$ is the fraction of non-production workers employed in industry i in 1960 and I_{ict} is the fraction (or estimated fraction) of the manufacturing employees in county c employed in industry i at time t. See Appendix C for details on the construction of the data.

To test whether trade changed the industrial composition of employment in manufacturing, I estimate regressions of the following form:

$$I_{ct} = \psi_c + \rho_t + \beta d_{1975} h_c + \gamma d_{1975} h_c s_{c,1950} + \delta d_{1975} s_{c,1950} + \varepsilon_{ct}. \quad (8)$$

[29] Similar calculations yield estimates that are close to 0 for a county with the mean level of education and about -1.3 for a county that is one s.d. below the mean level of education.

[30] Factor-content analysis typically assumes the absence of non-competing imports, no endogenous response of factor supplies to trade, and identical elasticities of substitution across all production functions and the utility function (Panagariya 2000).

I estimate the equation using OLS and IV, instrumenting the various interactions of the highway dummy with corresponding interactions of the two instruments. The estimated coefficients of interest, β and γ, are of the expected sign, but they are not statistically significant in any of the specifications (Table 9). Thus we cannot reject the hypothesis that trade has no effect on the industrial composition of employment.[31]

There are two possible ways to interpret the absence of significant effects of removing trade barriers on industrial composition. One approach is to interpret these results as evidence that the theoretical framework outlined in section 2 may be incomplete. For example, there may be frictions that restrict the mobility of labor across industries. My findings may also suggest that endogenous migration may have played only a limited role, since migration is likely to have reinforced the effects of trade on industrial composition (see Appendix B).[32] In related work, Goldberg and Pavcnik (2004) survey a number of recent studies that find very little effect of tariff reductions on industry composition in developing countries. These studies attribute their findings to imperfections of product markets or labor markets.

Alternatively, it is possible that my estimation strategy is not precise enough to estimate such effects.[33] For example, it may be that changes in labor demand have taken place at lower levels of industry aggregation or even within product classes (Schott 2004). Moreover, the absence of accurate employment data in many county-industry cells requires a process of imputation that may have resulted in non-negligible measurement error (see Appendix C). Further research may be needed to determine the extent to which the removal of trade barriers affects the industrial composition.

[31] Note that even if factors are not perfectly mobile across industries, trade could still affect the relative demand for skill by changing the relative prices of commodities.

[32] However, Card and Lewis (2005) find that even inflows of low-skilled workers had limited effects on the industrial composition in U.S. cities. Lewis (2005) argues that firms may vary the skill intensity of the production technique in response to migration.

[33] Revenga (1992) finds that U.S. industries faced with increasing import competition due to changes in exchange rates did reduce their employment and relative wages.

8 Concluding Remarks

The literature on international trade suggests that trade may affect the demand for skill, but it has proved difficult to identify this effect, since identification requires exogenous variation in the barriers to trade. In this paper I use the advent of the U.S. Interstate Highway System as a source of exogenous variation in trade barriers. The Interstate Highway System was built to better connect large cities, to serve national defense, and to connect with major routes in Canada and Mexico. As an unintended consequence of meeting these objectives, the highways crossed many rural counties. I find that the rural Interstate Highways were particularly important for the flow of large trucks. These highways increased trucking activity and retail sales by about 7-10 percentage points per capita in rural counties they crossed, relative to other rural counties.

Using the Interstate Highway System as a source of variation for trade, I test whether trade affected the demand for skill in rural areas. I find that on average, highways had no effect on the demand for high-skilled workers relative to low-skilled workers in manufacturing. However, highways increased the wage-bill of high-skilled workers relative to low-skilled workers in counties where skill was abundant, and reduced it where skill was scarce. This finding is consistent with the Heckscher-Ohlin view that trade increases the relative demand for the abundant factor. However, the magnitude of the effect is quite small: in a county that exceeds the mean level of education by one standard deviation, the elasticity of the wage-bill of non-production workers relative to production workers in manufacturing with respect to the ratio of domestic trade to local GDP is roughly equal to 1. In addition, I find no evidence for the prediction of the Heckscher-Ohlin model that trade significantly shifts the industrial composition of employment towards industries intensive in the abundant factor. This result suggests that changes in skill composition in response to reduced trade barriers may have taken place within industries or product classes, or that trade may have increased the demand for skill in skill-abundant counties through other channels.

My findings suggest that the ongoing expansion of trade between economies that differ in their skill endowment, such as trade between the developed world and the less-developed world, may continue to contribute to changes in labor market inequality. However, my results also indicate that opening to trade is not likely to explain a great deal of the variation in the demand for skill experienced by many countries in recent years.

Appendix A. Heckscher-Ohlin Model

In this appendix I extend the Heckscher-Ohlin model with a continuum of goods of Dornbusch, Fischer, and Samuelson (1980). The model assumes that differences in factor endowments determine the patterns and consequences of trade. The analysis begins with a single closed economy, and then considers two economies that differ only in their endowments and trade with each other. The model predicts that trade increases demand for the relatively abundant factor and shifts employment towards industries intensive in that factor. These predictions persist even when factor prices are not equalized and when migration between the economies is possible.

Consider an economy with two factors of production: a continuum H of high-skilled workers and a continuum L of low-skilled workers. There is a continuum of goods z on the interval $[0, 1]$. The production function for each good is

$$Q(z) = F_z \left(H(z), L(z) \right), \tag{9}$$

where $H(z)$ and $L(z)$ are the employment of high- and low-skilled labor in industry z. I assume that the production functions are twice continuously differentiable, increase in each of the arguments (with diminishing marginal returns), and satisfy constant returns to scale and the Inada conditions. The goods are ranked in a strictly decreasing order of skill intensity in production and there are no factor intensity reversals.[34] I assume that all factor and product markets are perfectly competitive with profit-maximizing firms and free entry.

Each consumer is endowed with one unit of labor of her type. Consumers are assumed to have an identical Cobb-Douglas utility function:

$$U = \int_0^1 b(z) \ln d(z) dz, \tag{10}$$

[34] In other words, I assume that the ranking of industries in terms of their relative skill intensity is invariant to factor prices.

where $d(z)$ is the quantity of good z consumed, and

$$\int_0^1 b(z)dz = 1. \tag{11}$$

The model thus assumes that income effects and differences in preferences play no role in determining the patterns of trade.

Closed Economy Equilibrium

I examine the existence and properties of a closed economy equilibrium, which is characterized by individual optimization, producer optimization and market-clearing. First, individuals maximize their utility subject to their budget constraint, so they spend a constant fraction $b(z)$ of their income on each good z at all prices and all levels of income.

Second, firms are competitive, so they maximize their profits

$$\pi(z) = P(z)Q(z) - w_H H(z) - w_L L(z), \tag{12}$$

where w_H and w_L are the wage rates for high- and low-skilled workers, and $P(z)$ is the price of good z. Free entry implies a zero profit condition:

$$P(z)Q(z) = w_H H(z) + w_L L(z). \tag{13}$$

Finally, the equality of supply and demand for every good implies:

$$P(z)Q(z) = b(z)\left(w_H H + w_L L\right). \tag{14}$$

Combining the last two expressions we get:

$$x(z) \equiv L(z)/L = \frac{b(z)(1+\omega h)}{1+\omega h(\omega; z)}, \tag{15}$$

where $x(z)$ the intensity of low-skilled labor in industry z relative to the economy as a whole, $\omega = w_H/w_L$ is the skill premium. The ratio of low- to high-skilled workers employed in the entire economy and in the production of good z are $h = H/L$ and $h(\omega; z) = H(\omega; z)/L(\omega; z)$. The market-clearing conditions for low- and high-skill labor are

$$\int_0^1 x(z)dz = 1 \text{ and } \int_0^1 x(z)h(\omega; z)dz = h. \tag{16}$$

Combining these expressions we get an equilibrium condition for the closed economy as a whole:

$$\phi(\omega; h) \equiv \int_0^1 \frac{b(z)(1+\omega h)}{1+\omega h(\omega; z)} \left[h(\omega; z) - h\right] dz = 0. \tag{17}$$

Since the production functions satisfy the Inada conditions, there are low values of ω such that $h(\omega; z)$ is higher than h for all z and hence $\phi(\omega; h)$ is positive at those values of ω; similarly, there high values of ω for which $\phi(\omega; h)$ is negative. Because the production functions are assumed to be neoclassical, $\phi()$ is continuous in ω. Thus there exists an equilibrium level of skill premium in autarky, $\omega = \omega^A$.

Next we note that $\phi(\omega; h)$ is strictly decreasing in ω:

$$\frac{\partial \phi(\omega; h)}{\partial \omega} < 0, \tag{18}$$

so the equilibrium skill premium is unique. The leftmost curve in Figure 1 shows the existence and uniqueness of the equilibrium skill premium in the closed home economy. Given the equilibrium skill premium, ω^A, relative price structure and the supply and demand of each good are uniquely determined.

Predictably, an increase in the skill endowment of the economy reduces the skill premium:

$$\frac{\partial \phi(\omega; h)}{\partial h}|_{\phi=0} = -1 \Rightarrow \frac{\partial \omega^A}{\partial h} = \left[\frac{\partial \phi(\omega; h)}{\partial \omega}\right]^{-1} < 0. \tag{19}$$

Open Economy Equilibrium

Consider opening the economy to trade with another such economy, which differs only in its factor endowments. The foreign economy has a high-skilled labor force of size H^* and a low-skilled labor force of size L^*. The foreign economy is assumed to have a lower fraction of skilled workers: $h^* \equiv H^*/L^* < h$. Figure 1 demonstrates that the equilibrium skill premium in the foreign economy, ω^{A*}, is higher than the skill premium in the home economy, as shown in (19).

First I analyze the equilibrium where the fraction of skilled workers does not differ greatly between the two economies, so trade equalizes factor prices (of course, if the fraction is identical trade has no effect).

Denote the home economy's share of low-skilled labor by $\xi = L/(L+L^*)$. The ratio of the stock of high-skilled workers to low-skilled workers in the two economies together is

$$\widehat{h} \equiv \frac{H+H^*}{L+L^*} = \xi h + (1-\xi)h^*. \tag{20}$$

Since factor prices are equal in both economies and the production technology is assumed to be identical, the factor requirements in producing both goods are the same in the two countries.

The equilibrium conditions for high-skilled labor in the two countries are:

$$\begin{aligned} H &= \int_0^1 \frac{\alpha(z)b(z)c(z)\left[(w_L L + w_H H) + (w_L L^* + w_H H^*)\right]}{P(z)} dz \text{ and} \\ H^* &= \int_0^1 \frac{(1-\alpha(z))\, b(z)c(z)\left[(w_L L + w_H H) + (w_L L^* + w_H H^*)\right]}{P(z)} dz, \end{aligned} \tag{21}$$

where $\alpha(z)$ is the fraction of total output of good z produced in the home economy. Producing one unit of commodity z requires $a(z)$ units of low-skilled labor and $c(z)$ units of high-skilled labor.

Combining the equations above we get an expression for the stock of high-skilled workers relative to low-skilled workers:

$$\int_0^1 \frac{b(z)h(\omega;z)(1+\omega\widehat{h})}{1+\omega h(\omega;z)}dz = \widehat{h}. \tag{22}$$

Similarly, by adding the equilibrium conditions for low-skilled labor we find that

$$\int_0^1 \frac{b(z)(1+\omega\widehat{h})}{1+\omega h(\omega;z)}dz = 1. \tag{23}$$

Putting together the results for both factors we have

$$\phi(\omega_{FPE}^T;\widehat{h}) = \int_0^1 \frac{b(z)(1+\omega_{FPE}^T\widehat{h})}{1+\omega h(\omega_{FPE}^T;z)}\left[h(\omega_{FPE}^T;z)-\widehat{h}\right]dz = 0, \tag{24}$$

where $\omega = \omega_{FPE}^T$ is the equilibrium skill premium with trade and factor price equalization.

Using (19) we conclude that opening to trade increases the skill premium in the home economy (which has a high skill endowment) and decreases it in the foreign economy (see Figure 1). Moreover, the effect of opening to trade on the skill premium increases with the difference in relative factor endowments. Since factor supply is assumed constant, the relative wage bill of skilled workers in the home economy, $S \equiv \omega h$, increases with trade. In the foreign economy, where skill is scarce, trade decreases the relative wage bill of skilled workers.

Because preferences for consumption goods are homothetic and identical, the skill composition of goods consumed in both economies is equal. The home economy employs more skill in production, so it must be a net exporter of skill. When trade equalizes factor prices all commodities can be produced at equal costs in both economies. The exact pattern of production (and trade) is thus indeterminate, except in one important respect: the skill-abundant economy will, on average, export skill-intensive goods. When trade leads to complete specialization, the pattern of trade is precisely determined, so the skill-abundant economy is also a net exporter of skill. We therefore conclude that opening to trade shifts production towards skill-intensive goods in the skill-abundant economy; the opposite is true for the skill-scarce economy.

Next consider the case where endowments differ sufficiently to give rise to complete specialization without equalizing factor prices in the two economies. Suppose that the home economy has a comparative advantage in producing a given good; then it has an advantage in producing all goods that are more skill-intensive. Thus, when the two economies trade, the home economy specializes in producing skill-intensive goods, while the foreign economy specializes in producing goods that are less skill-intensive. The threshold commodity, $\overline{z}$, is determined in equilibrium, such that its cost of production is equal in both economies:

$$P\left(\overline{z}\right) = P^{*}\left(\overline{z}\right) \Rightarrow w_{L}a\left(\overline{z}\right) + w_{H}c\left(\overline{z}\right) = w_{L}^{*}a^{*}\left(\overline{z}\right) + w_{H}^{*}c^{*}\left(\overline{z}\right), \tag{25}$$

where producing one unit of commodity z requires $a(z)$ units of low-skilled labor and $c(z)$ units of high-skilled labor. Since the skill premium in the home economy is lower ($\omega < \omega^{*}$), the threshold commodity is produced with a higher skill intensity in the home economy. The home economy produces the goods in the range $[0, \overline{z}]$ and imports goods in the range $[\overline{z}, 1]$. The total income in the home economy is $w_{L}L + w_{H}H$ and a fraction $\theta \equiv \int_{0}^{\overline{z}} b(z)dz$ of this income is spent on imported goods. The condition of balanced trade is therefore

$$\left(w_{L}L + w_{H}H\right)\theta = \left(w_{L}^{*}L^{*} + w_{H}^{*}H^{*}\right)\left(1-\theta\right). \tag{26}$$

The equilibrium conditions in the markets for low- and high-skilled labor in the home economy are

$$\begin{aligned} L &= \int_{0}^{\overline{z}} \frac{a(z)b(z)\left[\left(w_{L}L + w_{H}H\right) + \left(w_{L}^{*}L^{*} + w_{H}^{*}H^{*}\right)\right]}{P\left(z\right)}dz \text{ and} \\ H &= \int_{0}^{\overline{z}} \frac{c(z)b(z)\left[\left(w_{L}L + w_{H}H\right) + \left(w_{L}^{*}L^{*} + w_{H}^{*}H^{*}\right)\right]}{P\left(z\right)}dz. \end{aligned} \tag{27}$$

Combining these results with the balanced trade equation we get

$$\int_0^{\overline{z}} \frac{b(z)(1+\omega h)}{1+\omega h(\omega;z)} \left[h(\omega;z)-h\right] dz = 0. \tag{28}$$

The unique equilibrium is characterized by the wage ratio in the home economy, $\omega = \omega^T$.[35] Skill intensity declines in z, so $h(\omega; z) < h$ for all $z > \overline{z}$. We therefore conclude that

$$\phi(\omega^T; h) = \int_0^1 \frac{b(z)(\omega^T + \omega^T h)}{\omega^T + \omega^T h(\omega^T; z)} \left[h(\omega;z)-h\right] dz < 0. \tag{29}$$

Comparing this result with the closed economy equilibrium and using the fact that ϕ is decreasing in the skill premium, we conclude that $\omega^T > \omega^A$. Hence opening to trade increases the skill premium in the home economy. A similar calculation for the foreign economy indicates that it, too, has a unique skill premium, ω^{T*}, and that $\omega^{T*} < \omega^{A*}$. In other words, when the foreign economy opens to trade the skill premium in this economy declines.

Since factor endowments are assumed constant in this case, trade increases the relative wage bill of the locally abundant factor. In addition, since trade leads to specialization, each economy clearly shifts production towards goods intensive in the locally abundant factor in response to opening to trade.

Appendix B. Open Economy with Endogenous Migration

This Appendix extends the analysis to account for the possibility that workers migrate in response to the change in relative wages induced by the opening to trade. I assume that people differ in their preferences for living in either of the two economies, and that their

[35] There is a unique equilibrium skill premium because the competitive equilibrium maximizes total output with respect to (L, H, L^*, H^*), subject to the two resource constraints for each economy. The four endogenously determined variables are the the skill premia in the two economies (ω^T, ω^{T*}), the ratio of skilled wages in the two economies (w_H/w_H^*), and the threshold commodity $(\overline{z})$. The problem is convex, and hence there is a unique solution.

preferences are correlated with their skill:

$$U_{ijk} = \theta_1 \int_0^1 b(z) \ln d_i(z) dz + (1 - \theta_1) \ln \widetilde{q}_i + \theta_2 I_{ij} I_{ik}, \tag{30}$$

where U_{ijk} is the utility of a person i with skill level $j \in \{H, L\}$, and the subscript k denotes home or foreign economy. The consumption of good z is denoted by $d_i(z)$ and housing is denoted by $\widetilde{q}_i$. I_{ij} is an indicator for whether person i is skilled, I_{ik} is an indicator for living in the home economy and θ_2 is the preference of skilled workers for living in the home economy. I assume that the supply of housing in each of the economies is constrained by a fixed supply of land, $\widetilde{q}_k$:

$$\int_i I_{ik} \widetilde{q}_i di = \widetilde{q}_k. \tag{31}$$

A group of high-skilled workers of measure 1 residing in economy k consumes $d^H(z) = \theta_1 b(z) \frac{w_k^H}{P_k(z)}$ units of good z and $\frac{\omega_k \widetilde{q}_k}{(1+\omega_k h) L_k}$ units of housing. Similarly, a group of low-skilled workers of measure 1 residing in economy k consumes $d^L(z) = \theta_1 b(z) \frac{w_k^L}{P_k(z)}$ units of good z and $\frac{\widetilde{q}_k}{(1+\omega_k h) L_k}$ units of housing. If all goods are produced at home (or if trade equalizes factor prices) then $d^H(z) = \theta_1 b(z) \frac{\omega_k f_z(h(\omega_k; z))}{1+\omega_k h(\omega_k; z)}$ and $d^L(z) = \theta_1 b(z) \frac{f_z(h(\omega_k; z))}{1+\omega_k h(\omega_k; z)}$.[36] Hence their indirect utility of type j residing in country k as a function of the skill premium and the population of low-skilled workers is:

$$\begin{aligned} U_{ijk}(\omega_k, L_k) = \theta_1 \int_0^1 b(z) \ln \left(\theta_1 b(z) \frac{(\omega_k I_{ij} + (1 - I_{ij})) f_z(h(\omega_k; z))}{1 + \omega_k h(\omega_k; z)} \right) dz + \\ + (1 - \theta_1) \ln \left(\frac{(\omega_k I_{ij} + (1 - I_{ij}))}{(1 + \omega_k h) L_k} \widetilde{q}_k \right) + \theta_2 I_j I_k, \end{aligned} \tag{32}$$

where $f_z(h(\omega_k; z)) = F_z(H(z), L(z)) / L(z)$ is output per low-skilled worker in producing good z.

In order to analyze the effect of trade on the utility of both types, consider the utility of a representative agent in economy k, who owns 1 unit of low-skilled labor and h units of

[36] To derive the last two equations notice that $P_k(z) = a(z) w_k^L + c(z) w_k^H$, $h(z) = c(z)/a(z)$ and $a(z) = [f_z(h(\omega_k; z))]^{-1}$.

high-skilled labor.[37]

$$U_{ik}\left(\omega_k, L_k\right) = \theta_1 \int_0^1 b(z) \ln\left(\theta_1 b\left(z\right) \frac{\left(\omega_k h + 1\right) f_z\left(h(\omega_k; z)\right)}{1 + \omega_k h(\omega_k; z)}\right) dz + \\ + \left(1 - \theta_1\right) \ln\left(\frac{\widetilde{q}_k}{L_k}\right). \tag{33}$$

Assume that production functions are Cobb-Douglas and trade equalizes factor prices (before migration takes place), so the elasticity of substitution between high- and low skilled labor is one. In this case the relative wage bill of skilled workers in each industry, $\omega_k h(\omega_k; z)$, is constant. The first welfare theorem implies that the choice of inputs maximizes the welfare of the representative agent (33). Since $\omega_k h(\omega_k; z)$ is constant, the choice of inputs maximizes: $\int_0^1 b(z) \ln f_z\left(h(\omega_k; z)\right) dz$ given ω_k. Therefore, using the envelope theorem:

$$\frac{\partial}{\partial \omega_k}\left[\int_0^1 b(z) \ln f_z\left(h(\omega_k; z)\right) dz\right] = 0. \tag{34}$$

Using (34), we conclude that when production functions are Cobb-Douglas, $\frac{\partial U_{iHk}(\omega_k)}{\partial \omega_k} > 0$ and $\frac{\partial U_{iLk}(\omega_k)}{\partial \omega_k} < 0$, so high-skilled workers prefer a higher skill premium, while low-skilled workers prefer a lower skill premium. Since $\frac{\partial U_{iHk}(\omega_k)}{\partial L_k} < 0$ and $\frac{\partial U_{iLk}(\omega_k)}{\partial L_k} < 0$, both types prefer a lower population of low-skilled workers in their economy (holding relative wages fixed), because a higher population implies higher housing prices. By continuity, these results also hold if the elasticity of substitution in production of all goods is sufficiently close to one.

In order to analyze the equilibrium, it is convenient to begin by considering the case where free migration is possible but there is no trade between the two economies. I focus on the case where workers choose to live in both economies.[38] If $\theta_2 = 0$ there is a symmetric equilibrium

[37] To simplify the analysis I assume that the representative agent derives no utility from living in either economy.

[38] There are also two other equilibria in which all the workers reside in either of the two economies. In this case no worker has an incentive to migrate, because production (and positive wages) are only possible with both types of workers.

in which both economies have an equal number of workers. To prove the existence and uniqueness of this equilibrium, consider the conditions for indifference of the two types of workers between the two economies. As figure A1 shows, the indifference curve of high-skilled workers between the two economies (U_H) is upward sloping in the space of the home economy skill premium, ω, and the relative supply of low-skilled labor L/L^*, while the indifference curve for low-skilled workers (U_L) is downward sloping. Holding all else constant, as ω approaches zero high-skilled workers require a lower level of L/L^* than low-skilled workers to be indifferent between the two economies. Similarly, if ω is high enough, low skilled workers require a lower level of L/L^* than high-skilled workers for indifference. Since the utility functions are continuous, there is a unique equilibrium combination of ω and L/L^*. Given a fixed aggregate supply of high- and low-skilled labor in both economies together, ω and L/L^* determine a unique level of h in the home economy. This, in turn, implies a unique level of employment of skilled workers in the foreign economy and hence a unique skill premium ω^*.

Now consider the case where high-skill workers prefer to live in one of the two economies ($\theta_2 \neq 0$). Without loss of generality I assume that $\theta_2 > 0$, so ceteris paribus high-skilled workers prefer to reside in the home economy. The indifference curve for the high-skilled workers is below the indifference curve corresponding to $\theta_2 = 0$ (see indifference curve U'_H Figure 1). In equilibrium the skill premium ω and the relative employment of low-skilled labor (L/L^*) are lower. High-skill workers are indifferent between the two economies because the price and wage differentials offset their preference for the home economy. Low-skilled workers are also indifferent because in the home economy they have higher wages and a higher price of housing.

Suppose that $\theta_2 > 0$ and the economies open to trade with each other. Assume that there is no initial response of migration and that factor endowments do not differ too much, so initially trade equalizes factor prices. The equilibrium analysis is identical to the cases outlined without migration, except that now the fraction of income spent on each good z

is a fraction θ_1 of its share when there was no expenditure on housing. As we saw, trade raises the skill premium in the home economy and decreases it in the foreign economy. Since factor prices are equalized, high-skilled workers migrate to the home economy, raising the price of housing. Therefore low-skilled workers migrate to the foreign economy. In equilibrium, the wage premium in the home economy must be lower than in the foreign economy (otherwise all high-skilled workers choose to reside in the home economy, as do all low-skilled workers). However, if we assume that on aggregate high- and low-skilled labor are not gross complements, trade increases the wage-bill share of the abundant factor in each economy.

In summary, when migration is costless trade increases the wage-bill share of high-skilled workers in the skill intensive economy by increasing their relative employment. To the extent that migration is costly, the increase is mainly due to a change in relative wages. Migration also induces a larger change in the composition of production due to Rybczynski effects: an increase in the share of high-skilled workers increases the skill content of production and exports of the home economy.

Appendix C. Industrial Composition Data

The data on each county's employment in 2-digit SIC industries are from the County Business Patterns data set. For 1977-1997 I use publicly available data from the University of Virginia, and for 1967 and 1972 I use data from the University of California Berkeley Data Center. There are two important differences between the two sources of data. First, industries were re-classified in the 1970s, so I exclude from the data SIC 19 (Ordinance), which only exists for the earlier years. Second, the earlier data are reported only for county-industry cells with 100 employees or more or at least 10 establishments. Moreover, the data reports employment by establishment size categories, which have changed slightly over time, and exact overall employment is not reported for all counties. In order to solve these problems I assume that the employment in an establishment with a given size category is the geometric average of the category's two limits. I then use a regression to predict the employment in establishments in the largest size category for each year. When total employment is not available I predict it using a regression. Finally, to ensure comparability over time, I exclude county-industry cells with less than 10 establishments or with fewer than 100 workers (or fewer than 100 predicted workers) for 1977-1997. Using this data I calculate the fraction of manufacturing employees in each county, industry, and year.

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Table 1. County descriptive statistics

Mean	Earliest data (post-WWII)	All counties	Sample counties		
			Full Sample	With highway	Without highway
Land Area	1950	959	988	1,238	906
Population	1950	48,699	19,378	24,858	17,590
Population density	1950	213	32	38	30
Population growth	1930-1950	0.004	0.001	0.004	-0.001
Per capita income	1959	1,352	1,237	1,319	1,210
Earnings in trucking and warehousing per capita	1969	44	42	41	42
Retail sales per capita	1948	693	630	678	614
High-school graduates (of 25+ years old)	1950	0.27	0.25	0.27	0.25
Fraction commuting to work outside county	1970	0.20	0.20	0.22	0.19
Distance to nearest large city (miles)		84	92	78	96
Northeast		0.07	0.04	0.04	0.04
Midwest		0.34	0.36	0.30	0.38
South		0.46	0.46	0.44	0.47
West		0.13	0.14	0.22	0.11
Observations		3,101	2,000	492	1,508

Notes: The summary statistics are from the County and City Data books and from authors calculations using the National Transportation Atlas Databases, and they are calculated for all counties for which land area in known for 1950. Income, earnings, and sales data are in nominal US dollars.

Table 2. Determinants of highway assignment to counties

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Highway planned in 1944 legislation	0.795	0.798	0.842	0.789	0.785						0.780	
	(0.024)	(0.023)	(0.016)	(0.024)	(0.025)						(0.025)	
Direction to nearest city instrument						0.218	0.221	0.186	0.231	0.232	0.055	0.270
						(0.051)	(0.052)	(0.034)	(0.051)	(0.048)	(0.040)	(0.048)
1950 population weights	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Distance to nearest city	No	No	No	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes
Geographic indicators	None	Region	Region	Region	State	None	Region	Region	Region	State	Region	Region

Notes: Cross-section regressions for sample counties. Columns 1-11 use full sample of counties (2000 observations) and column 12 uses only counties in the Midwest and the South (1647 observations). Robust standard errors are in parenthesis.

Table 3. Vehicle miles traveled on rural interstate highway, by vehicle type

	1970			1980			1990		
Vehicle miles traveled (billions)	Rural Interstate Highways	Other highways	Fraction traveled on rural highways	Rural Interstate Highways	Other highways	Fraction traveled on rural highways	Rural Interstate Highways	Other highways	Fraction traveled on rural highways
Combination trucks	8.1	27.0	0.23	21.1	47.6	0.31	30.1	64.2	0.32
Single-unit trucks	2.0	25.1	0.07	4.0	35.8	0.10	5.7	46.2	0.11
Passenger cars and motorcycles	62.3	857.3	0.07	89.5	1,032.3	0.08	117.5	1,300.3	0.08
Other vehicles	7.1	120.7	0.06	20.5	276.5	0.07	46.9	533.4	0.08
Total	79.5	1,030.2	0.07	135.1	1,392.2	0.09	200.2	1,944.2	0.09

Notes: The data are from Highway Statistics, 1995-2000. The figures include vehicle miles traveled on toll highways incorporated into the Interstate Highway System, since data for those segments are not reported separately.

Table 4. Effect of highways on ln(earnings in trucking and warehousing per capita)

	(1)	(2)	(3)	(4)	(5)
1972	0.022	0.026	0.009	0.028	0.027
	(0.021)	(0.021)	(0.023)	(0.021)	(0.021)
1977	0.074	0.084	0.069	0.083	0.077
	(0.031)	(0.032)	(0.031)	(0.032)	(0.032)
1982	0.061	0.079	0.083	0.093	0.082
	(0.037)	(0.038)	(0.040)	(0.039)	(0.037)
1987	0.078	0.090	0.090	0.100	0.088
	(0.043)	(0.043)	(0.045)	(0.044)	(0.043)
1992	0.115	0.149	0.158	0.154	0.144
	(0.049)	(0.048)	(0.049)	(0.049)	(0.048)
1997	0.041	0.086	0.117	0.093	0.089
	(0.052)	(0.050)	(0.051)	(0.051)	(0.051)
Observations	12,220	12,220	12,220	12,220	12,220
Weights	Yes	Yes	No	Yes	Yes
Region*year	No	Yes	Yes	Yes	Yes
Distance*year	No	No	No	Yes	Yes
1950 Pop. density*year	No	No	No	No	Yes

Notes: All estimates are from a panel of the sample counties that includes county and year dummies. Each column reports highway*year interactions from a seperate regression, and the omitted interaction is highway*1969. The weights are 1950 population. Robust standards errors in parenthesis are clustered at the county level. Distance denotes the distance in miles from the county centroid to the nearest large city.

Table 5. Effect of highways on ln(retail sales per capita)

	(1)	(2)	(3)	(4)	(5)
1954	-0.013	-0.002	-0.010	-0.003	0.000
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
1958	-0.031	-0.018	-0.032	-0.016	-0.011
	(0.012)	(0.010)	(0.010)	(0.010)	(0.010)
1963	-0.029	-0.011	-0.033	-0.007	-0.003
	(0.014)	(0.011)	(0.011)	(0.011)	(0.011)
1967	-0.027	-0.001	-0.019	-0.005	-0.002
	(0.017)	(0.014)	(0.014)	(0.014)	(0.014)
1972	0.023	0.042	0.032	0.033	0.032
	(0.020)	(0.015)	(0.016)	(0.015)	(0.016)
1977	0.034	0.053	0.051	0.045	0.043
	(0.020)	(0.016)	(0.017)	(0.016)	(0.017)
1982	0.057	0.078	0.078	0.072	0.070
	(0.023)	(0.018)	(0.020)	(0.019)	(0.019)
1987	0.076	0.102	0.107	0.086	0.080
	(0.025)	(0.021)	(0.021)	(0.020)	(0.020)
1992	0.087	0.110	0.118	0.095	0.089
	(0.025)	(0.021)	(0.022)	(0.020)	(0.021)
1997	0.101	0.135	0.149	0.123	0.117
	(0.027)	(0.022)	(0.024)	(0.022)	(0.022)
Observations	21,839	21,839	21,839	21,839	21,839
Weights	Yes	Yes	No	Yes	Yes
Region*year	No	Yes	Yes	Yes	Yes
Distance*year	No	No	No	Yes	Yes
1950 Pop. density*year	No	No	No	No	Yes

Notes: All estimates are from a panel of the sample counties that includes county and year dummies. Each column reports highway*year interactions from a seperate regression, and the omitted interaction is highway*1948. The weights are 1950 population. Robust standards errors in parenthesis are clustered at the county level. Distance denotes the distance in miles from the county centroid to the nearest large city.

Table 6. Effect of highways on trade and commuting

	OLS						IV		
							Instrument		
							1944 plan	Direction to city	
	Full Sample					Midwest and South	Full Sample	Full Sample	Midwest and South
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
A. Dependent variable: ln(retail sales per capita): 1963-1997									
Highway*(post-1975)	0.082	0.086	0.107	0.081	0.071	0.063	0.082	0.121	0.144
	(0.013)	(0.012)	(0.014)	(0.012)	(0.012)	(0.013)	(0.015)	(0.086)	(0.082)
Observations	15,854	15,854	15,854	15,854	15,854	13,053	15,854	15,854	13,053
B. Dependent variable: ln(earnings in trucking and warehousing per capita): 1969-1997									
Highway*(post-1975)	0.063	0.084	0.098	0.074	0.082	0.088	0.054	0.070	0.180
	(0.033)	(0.033)	(0.033)	(0.032)	(0.032)	(0.039)	(0.043)	(0.228)	(0.217)
Observations	12,220	12,220	12,220	12,220	12,220	10,099	12,220	12,220	10,099
C. Dependent variable: fraction commuting to work outside their county of residence: 1970-1990									
Highway*(post-1975)	0.005	0.008	0.007	0.011	0.008	0.008	0.007	0.031	0.024
	(0.005)	(0.005)	(0.004)	(0.006)	(0.005)	(0.005)	(0.006)	(0.030)	(0.028)
Observations	5,874	5,874	5,874	5,874	5,874	4,815	5,874	5,874	4,815

Notes: All estimates are from a panel of the sample counties that includes county and year dummies. Robust standards errors in parenthesis are clustered by county. Each cell reports the coefficient on highway*(post-1975) interaction from a separate regression. Columns 2-9 control for region-specific year effects. All regressions are weighted using the 1950 population, except column 3 which is unweighted. Column 4 uses an index of highway completion, by state, instead of a post-1975 indicator. Columns 5-9 control for (distance to nearest city)*year and (1950 population density)*year interactions. Columns 6 and 9 limit the sample to the regions where the first stage is significant for the direction instrument (the Midwest and the South).

Table 7. Effect of highways on the demand for skill in manufacturing

	OLS					IV	
						Instrument	
						1944 plan	Direction to city
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
A. Dependent variable: ln(relative wage-bill of non-production workers)							
(Post-1975)*highway	0.006	-0.149	-0.168	-0.151	-0.101	-0.223	-1.370
	(0.024)	(0.069)	(0.068)	(0.077)	(0.069)	(0.094)	(2.049)
(Post-1975)*highway*(1950 hs)		0.623	0.609	0.564	0.456	0.802	4.177
		(0.249)	(0.241)	(0.262)	(0.247)	(0.312)	(5.960)
(Post-1975)*(1950 high school)		-0.443	-0.323	-0.208	-0.077	-0.278	-1.200
		(0.148)	(0.213)	(0.255)	(0.093)	(0.271)	(1.683)
Observations	5,795	5,795	5,793	4,455	4,455	4,455	4,455
B. Dependent variable: ln(relative wage of non-production workers)							
(Post-1975)*highway	-0.051	-0.129	-0.113	-0.113	-0.069	-0.136	-1.259
	(0.020)	(0.059)	(0.059)	(0.059)	(0.058)	(0.077)	(1.573)
(Post-1975)*highway*(1950 hs)		0.313	0.274	0.274	0.130	0.312	3.098
		(0.202)	(0.206)	(0.206)	(0.207)	(0.262)	(4.563)
(Post-1975)*(1950 high school)		-0.251	-0.479	-0.479	0.022	-0.484	-1.145
		(0.134)	(0.220)	(0.220)	(0.085)	(0.230)	(1.285)
Observations	4,456	4,456	4,455	4,455	4,455	4,455	4,455
C. Dependent variable: ln(relative employment of non-production workers)							
(Post-1975)*highway	0.063	-0.004	-0.037	-0.038	-0.032	-0.087	-0.111
	(0.027)	(0.081)	(0.079)	(0.079)	(0.075)	(0.096)	(1.646)
(Post-1975)*highway*(1950 hs)		0.264	0.289	0.290	0.326	0.490	1.079
		(0.278)	(0.267)	(0.267)	(0.268)	(0.320)	(4.808)
(Post-1975)*(1950 high school)		-0.134	0.276	0.272	-0.099	0.206	-0.055
		(0.179)	(0.257)	(0.258)	(0.103)	(0.276)	(1.373)
Observations	4,461	4,461	4,460	4,455	4,455	4,455	4,455

Notes: All estimates are from a panel of the sample counties that includes county and year dummies. All estimates use data for 1967-1982, and include 1950 population weights. Robust standards errors in parenthesis are clustered by county. Columns 1-3 use the full sample, and columns 4-7 use a fixed sample size across panels. Columns 3-7 control for region*year, (distance to nearest city)*year, and (1950 population density)* year interactions, and the fraction of high-school graduates among 25+ year-olds. Column 5 uses a state-level index of the fraction of highways completed.

Table 8. Effect of highways on the demand for skill in manufacturing

Dependent variable: change in ln(relative wage-bill of non-production workers)	OLS		IV	
			Instrument	
			1944 plan	direction to city
	(1)	(2)	(3)	(4)
A. Before highway construction was complete: 1947-1967				
Highway	-0.069	-0.052	0.049	0.209
	(0.120)	(0.119)	(0.159)	(1.385)
Highway*(1950 high school)	0.476	0.322	-0.062	-0.814
	(0.415)	(0.414)	(0.524)	(4.200)
(1950 high school)	-0.547	-0.754	-0.639	-0.391
	(0.248)	(0.381)	(0.394)	(1.178)
B. When highway construction was being completed: 1967-1982				
Highway	-0.140	-0.134	-0.228	0.719
	(0.089)	(0.089)	(0.106)	(1.307)
Highway*(1950 high school)	0.736	0.655	0.929	-2.202
	(0.309)	(0.309)	(0.360)	(3.920)
(1950 high school)	-0.335	-0.098	-0.167	0.702
	(0.199)	(0.280)	(0.298)	(1.091)
C. After the construction of highways was complete: 1982-1992				
Highway	0.047	0.082	0.077	-0.114
	(0.076)	(0.075)	(0.102)	(1.156)
Highway*(1950 high school)	-0.076	-0.233	-0.125	1.171
	(0.275)	(0.261)	(0.344)	(3.464)
(1950 high school)	0.243	-0.070	-0.116	-0.592
	(0.169)	(0.241)	(0.245)	(0.932)

Notes: Cross section regression using a fixed subsample of 1,072 counties for which data exists in 1947,1967,1982 and 1992. Columns 2-4 control for region dummies, distance to nearest city, and 1950 population density. Robust standards errors are in parenthesis.

Table 9. Effect of highways on industrial composition of manufacturing employment

	OLS				IV	
					Instrument	
					1944 plan	Direction to city
Dependent variable: index of non-production worker intensity	(1)	(2)	(3)	(4)	(5)	(6)
(Post-1975)*highway	-0.002	-0.007	-0.011	-0.012	-0.014	0.032
	(0.003)	(0.009)	(0.009)	(0.008)	(0.012)	(0.126)
(Post-1975)*highway*(1950 hs)		0.020	0.030	0.032	0.035	-0.075
		(0.029)	(0.031)	(0.029)	(0.040)	(0.386)
(Post-1975)*(1950 high school)		0.001	0.031	0.001	0.031	0.052
		(0.017)	(0.026)	(0.009)	(0.027)	(0.096)
Observations	5,818	5,818	5,813	5,813	5,813	5,813

Notes: All estimates are from a panel of the sample counties that includes county and year dummies. All estimates use data for 1967-1982, and include 1950 population weights. Robust standards errors in parenthesis are clustered by county. Columns 3-6 control for region*year, (distance to nearest city)*year, and (1950 population density)*year interactions, and the fraction of high-school graduates among 25+ year-olds. Column 4 uses a state-level index of the fraction of highways completed.

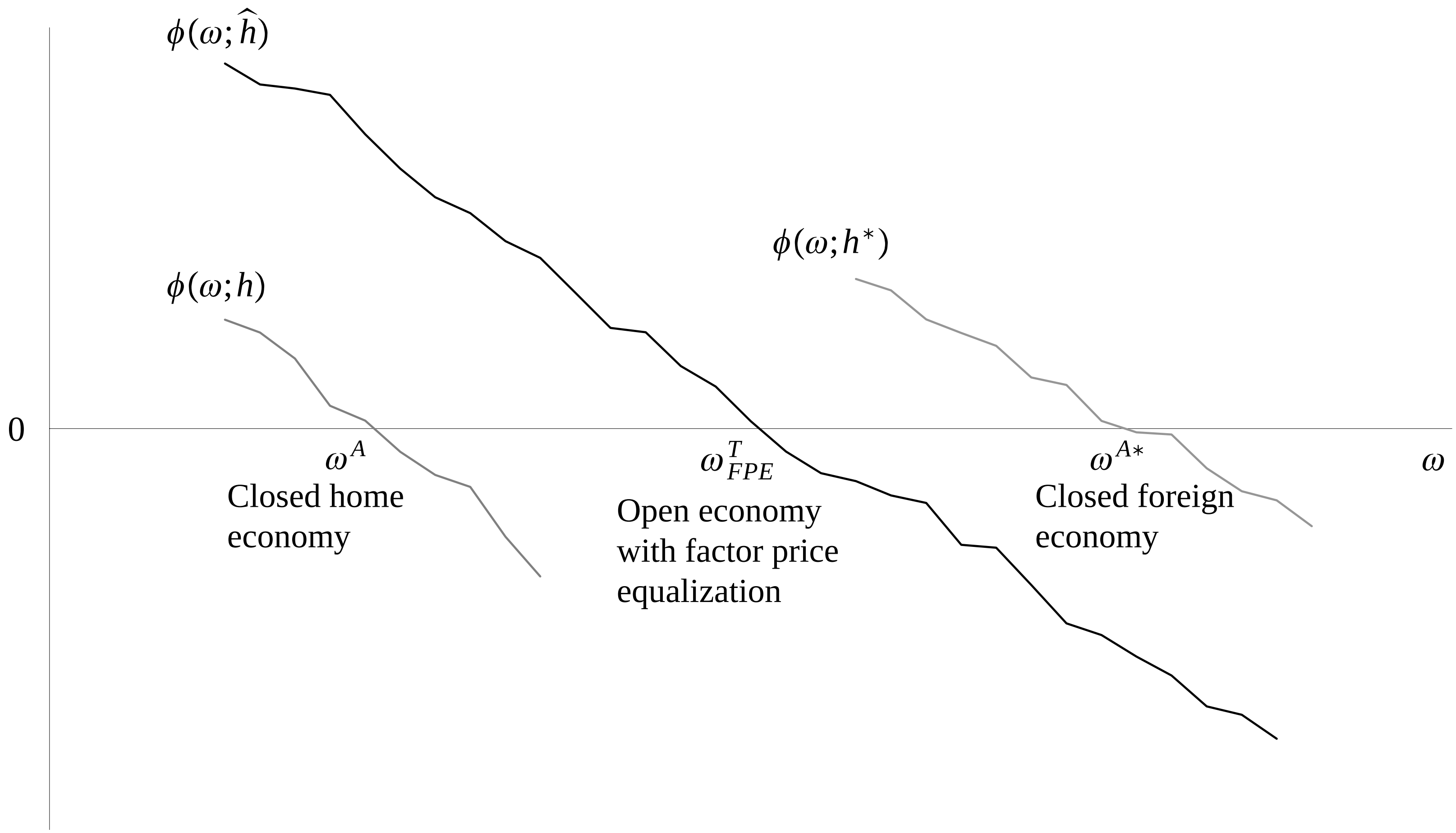

Figure 1. Existence and uniqueness of the equilibrium skill premium without migration. Holding the endowment fixed (along each of the curves), ϕ is positive for low skill premia and negative for high skill premia. Since it is continuous and decreasing in the skill premium there is a unique equilibrium skill premium such that $\phi = 0$.

Figure 2. Routes of the recommended interregional highway system, 1944 plan. Source: U.S. House of Representatives, *Interregional Highways*, Washington D.C.: Government Printing Office, House document no. 379, 78th congress, 2nd session, January 1944

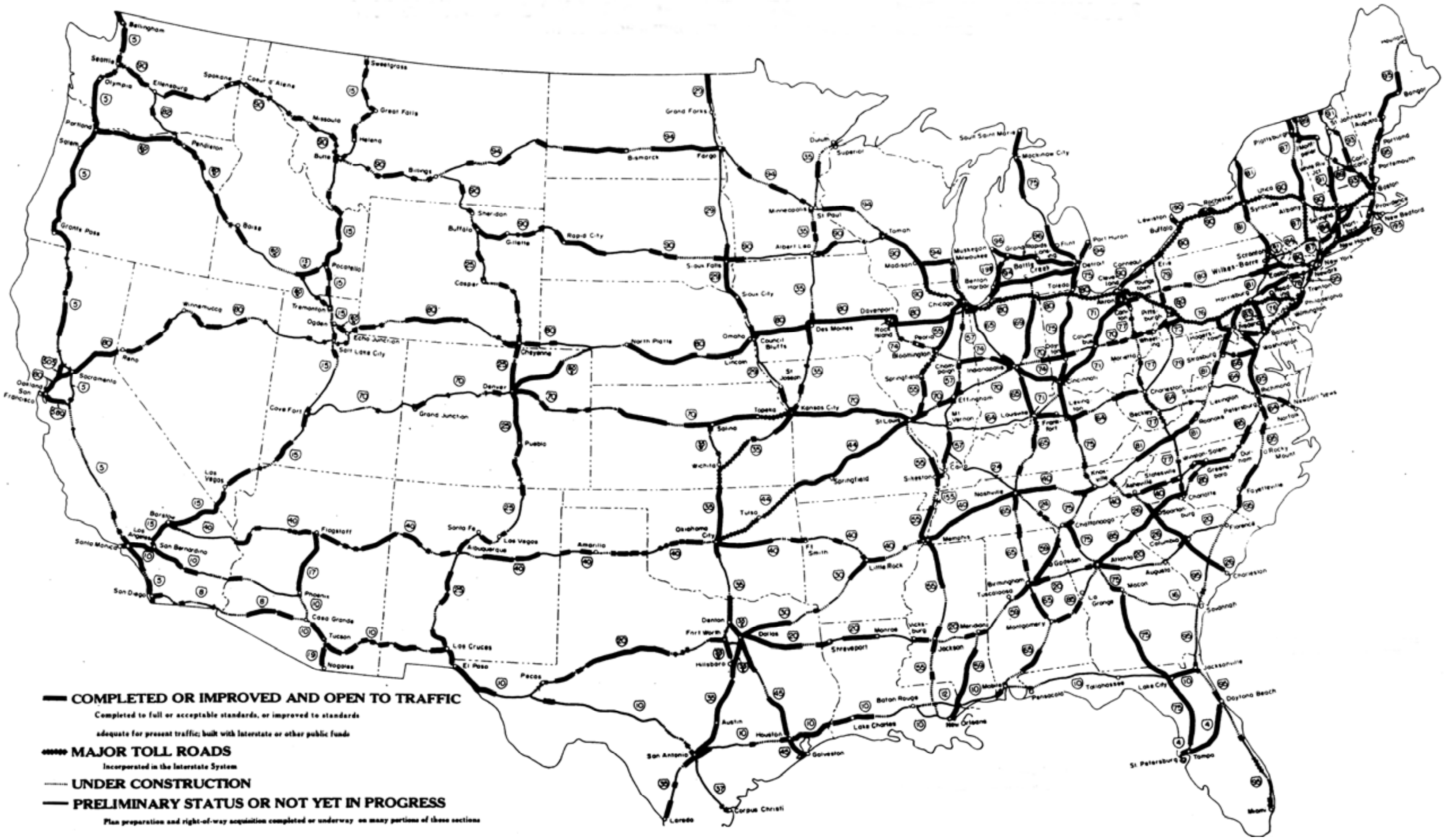

Figure 3. The Interstate Highway System in September 1966. Source: Bureau of Public Roads.

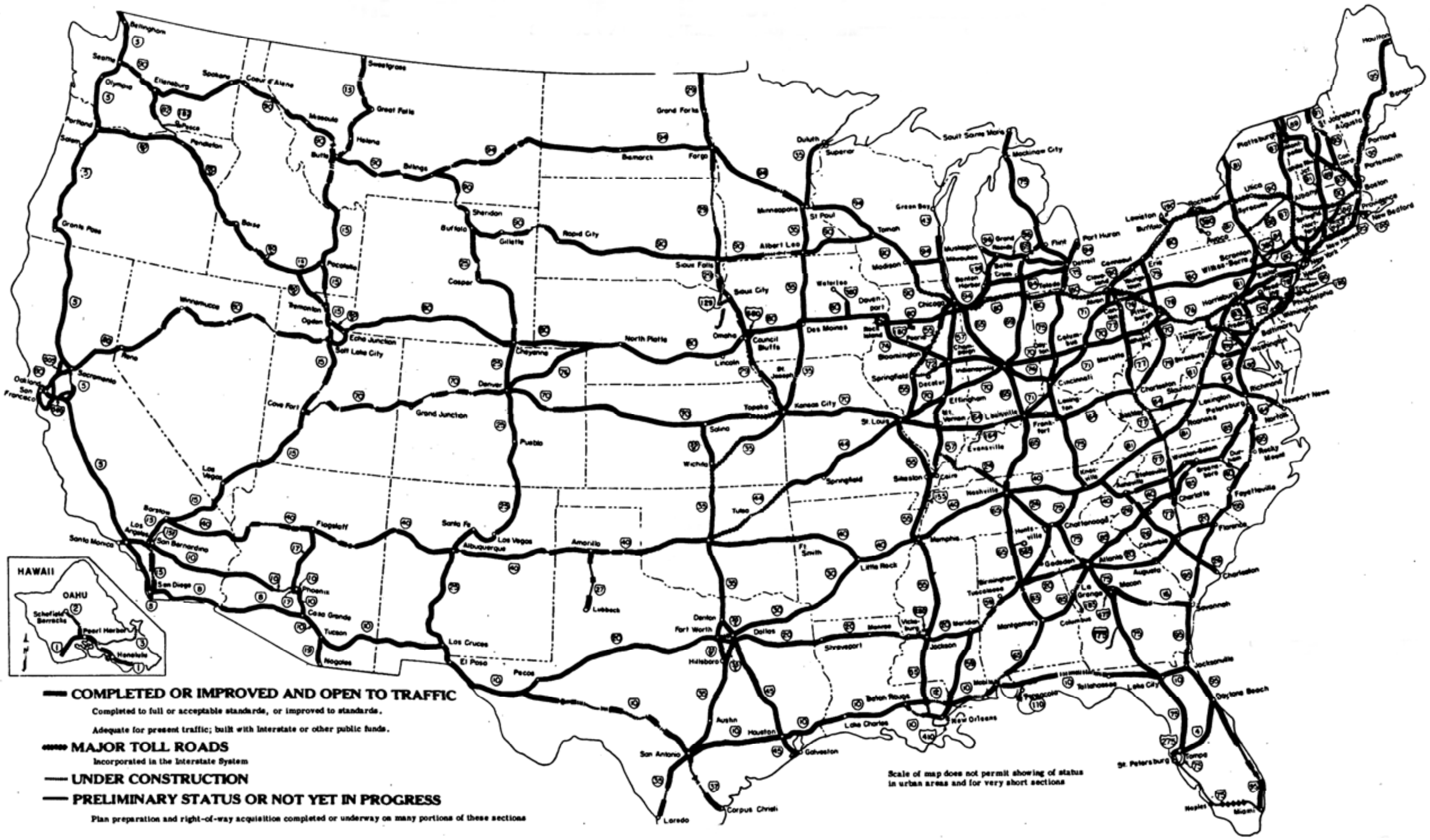

Figure 4. The Interstate Highway System in December 1975. Source: Federal Highway Administration.

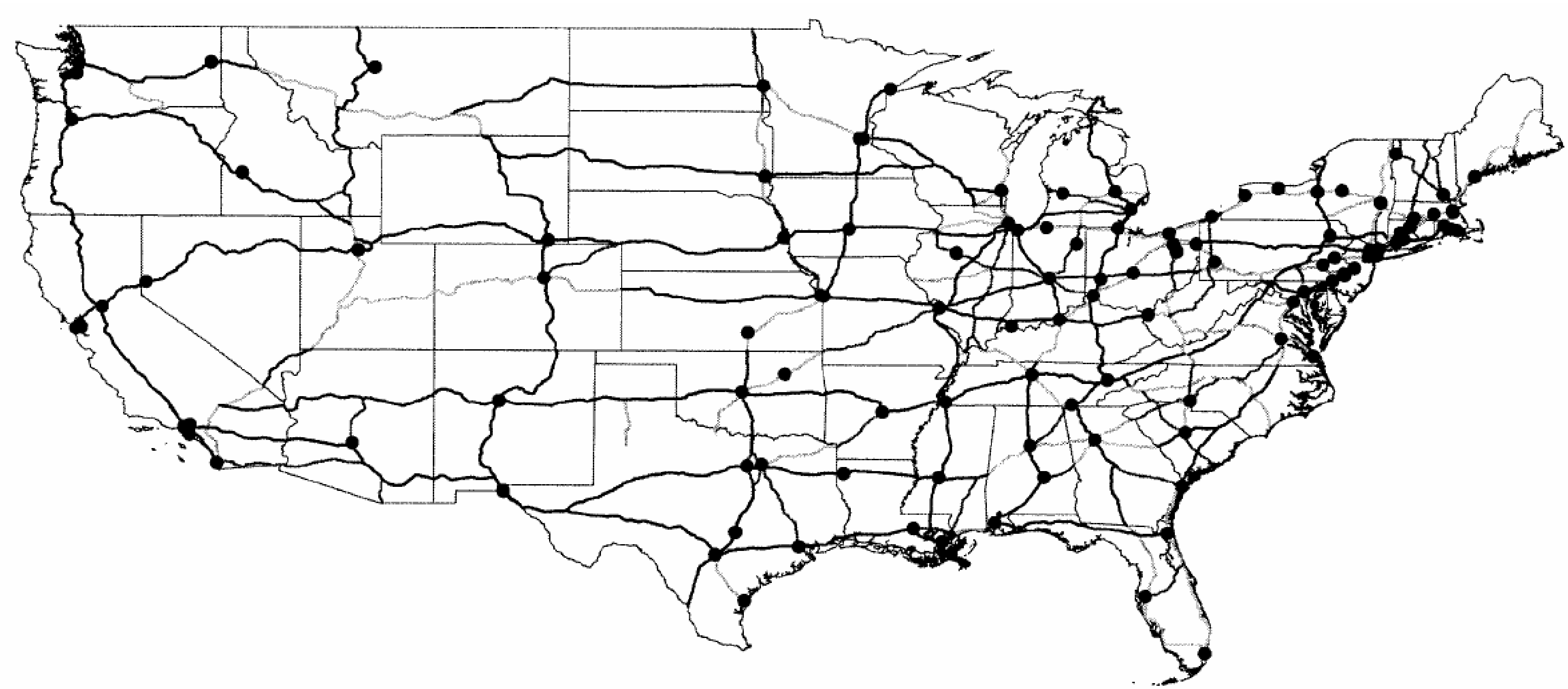

Figure 5. The Interstate Highway System in 2002. Black lines denote highways segments included in the sample and grey lines denote highway segments excluded from the sample. Black dots denote cities that had a population of 100,000 or more or were the largest in their state in 1950.

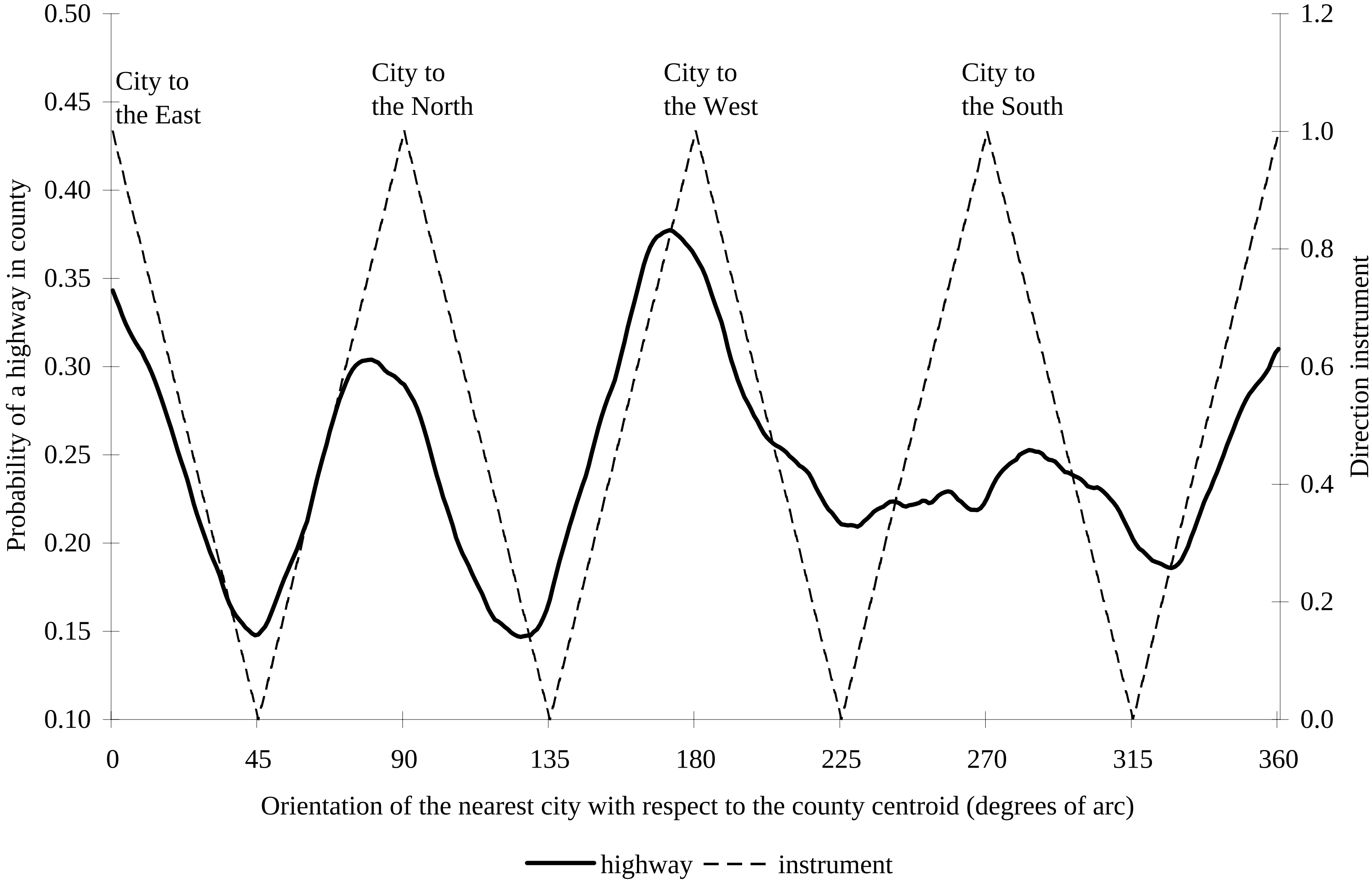

Figure 6. The direction to the nearest city and the probability an interstate highway crosses a rural county. The probability is estimated using a kernel regression with an Epanechnikov kernel and a bandwidth of 20.

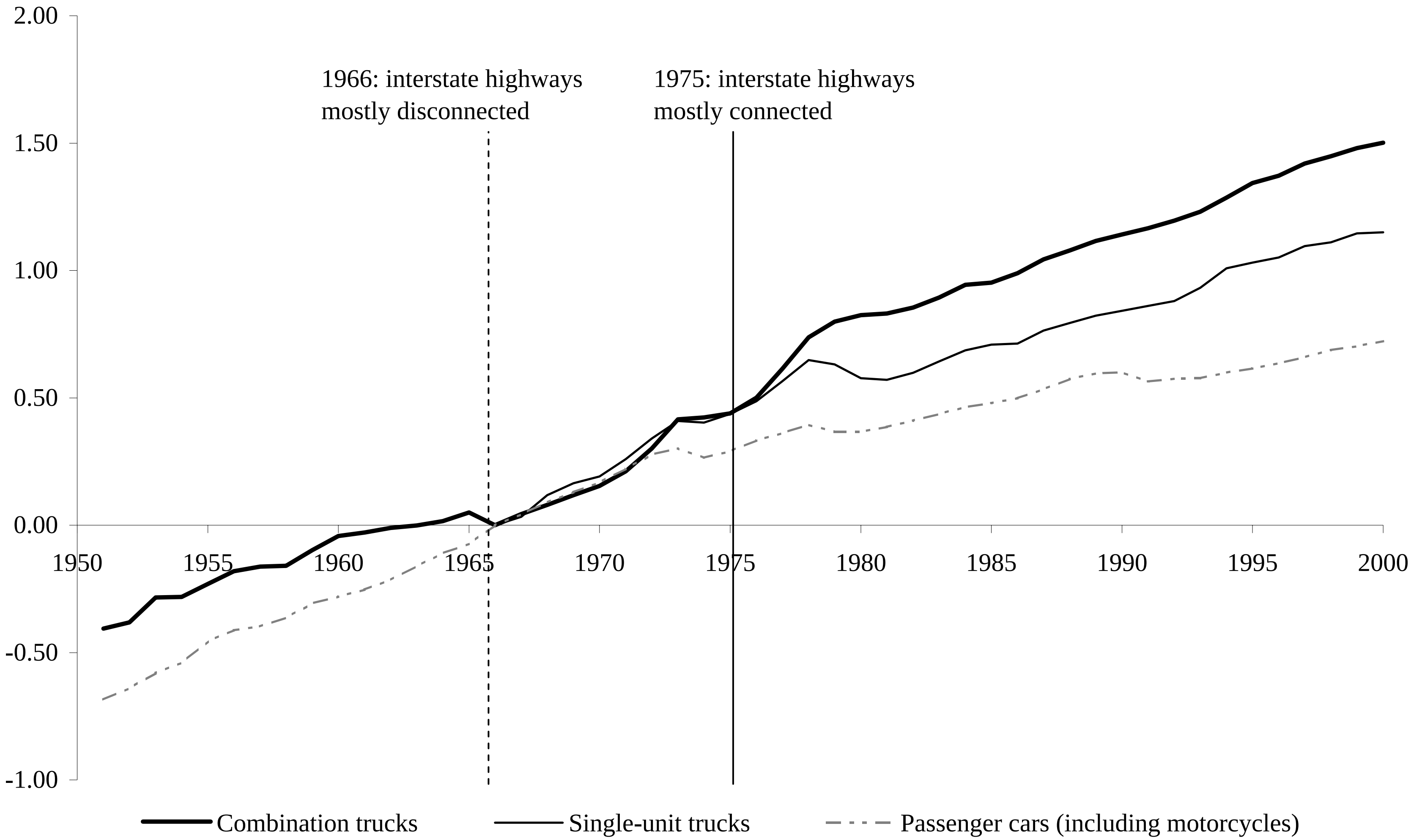

Figure 7. Ln(vehicle miles traveled), by vehicle type (base year is 1966). Source: U.S. Department of Transportation, Federal Highway Administration, Office of Highway Policy Information, Highway Statistics

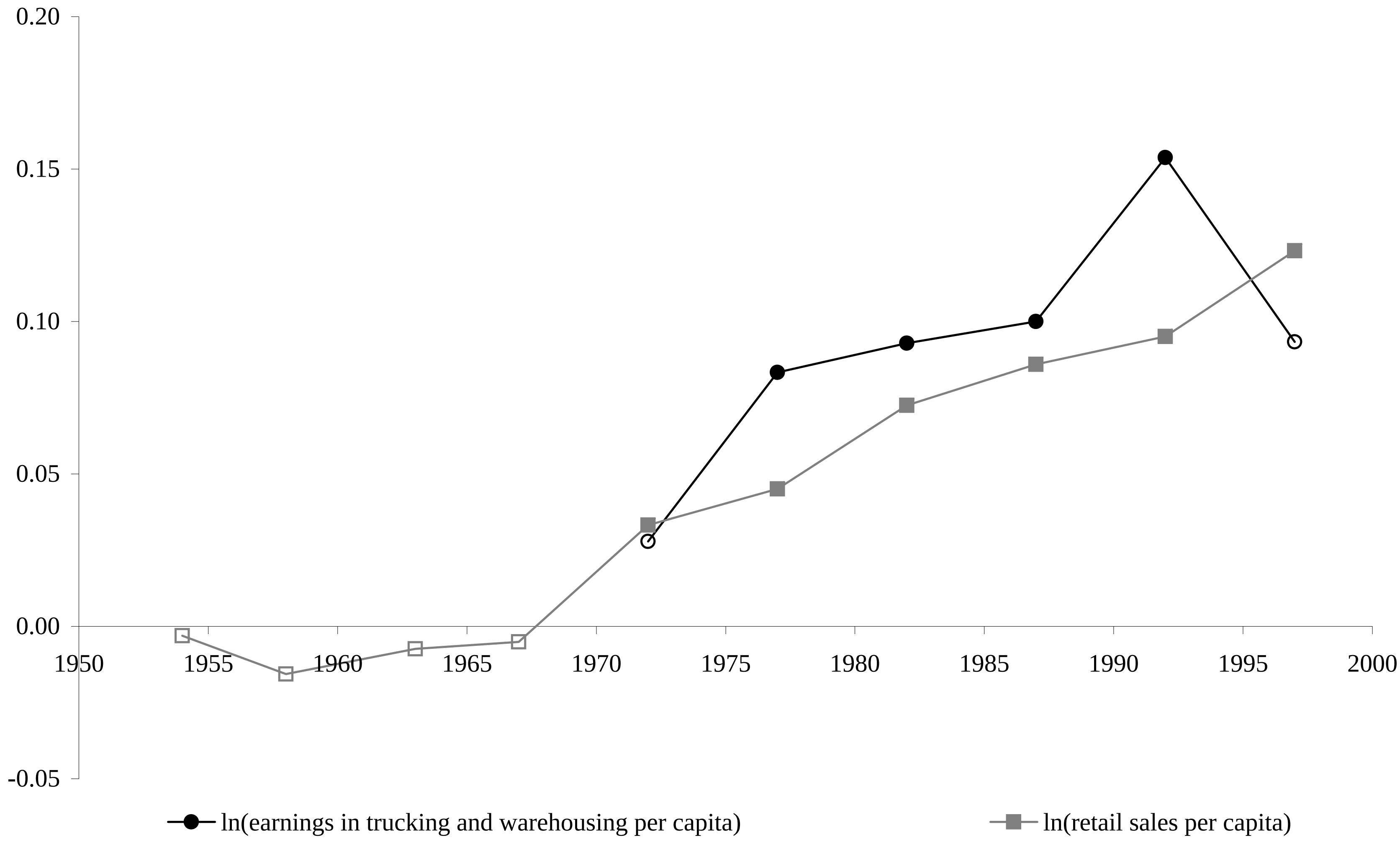

Figure 8. The effect of highways on trade in rural counties. The figure reports the coefficients on highway*year interactions from Column 4 in Tables 4 and 5. Open points represent coefficients not significant at the 5 percent level.

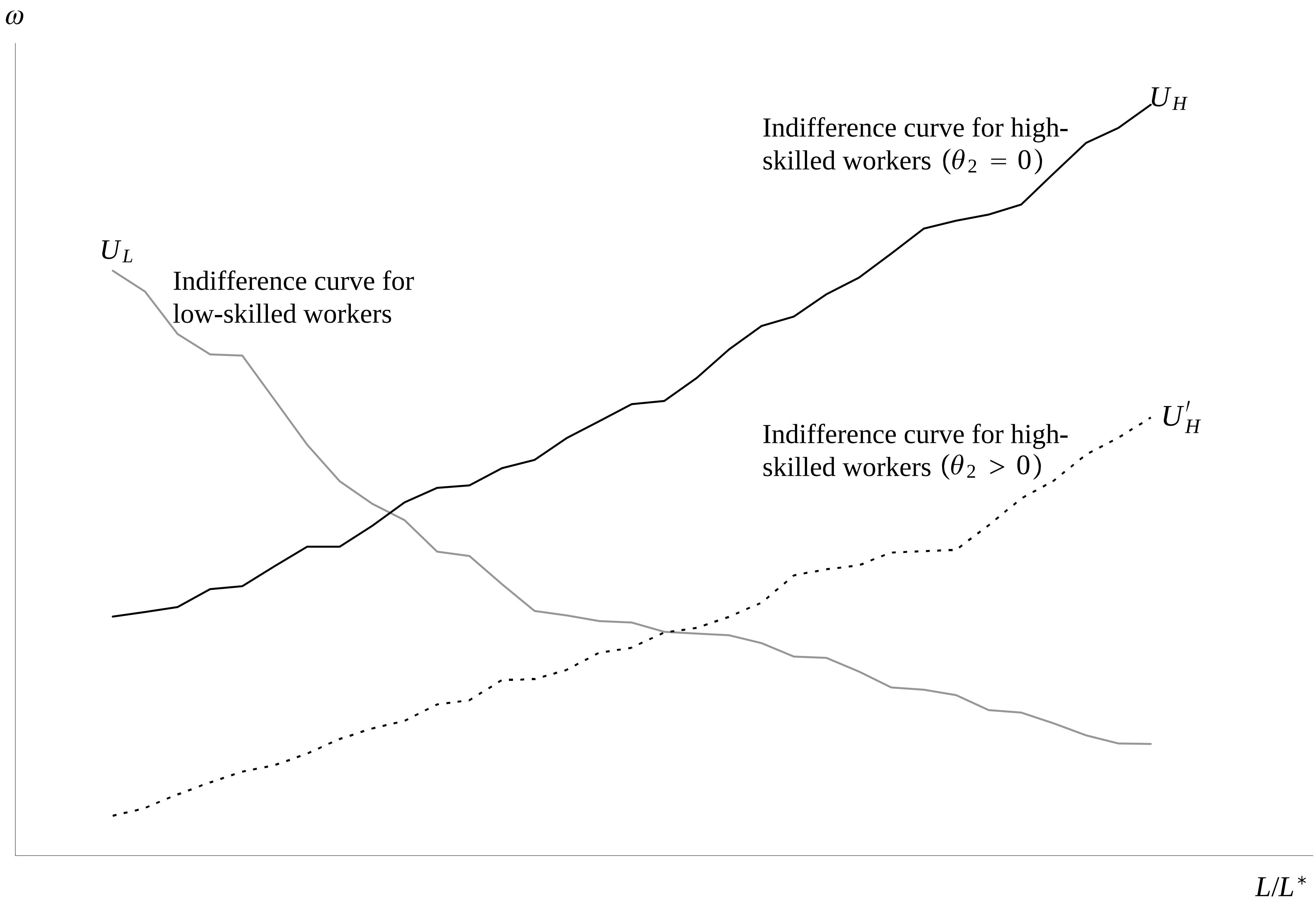

Figure A1. Existence and uniqueness of the equilibrium with migration.