Is a Skill Intensity Reversal a Mere Theoretical Curiosum?
Evidence from the U.S. and Mexico

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Abstract

A rising skill premium in two countries can be explained by the Heckscher-Ohlin model assuming a “skill intensity reversal.” This assumption, however, poses an empirical challenge since past research has found little evidence for the so-called “factor intensity reversal.” We now show clear-cut evidence: U.S. net exports to Mexico of electronics products—relatively high-skill intensive within the U.S. but relatively low-skill intensive within Mexico—increased from 1994 to 2000. U.S. net imports from Mexico of non-electronics products—relatively low-skill intensive within the U.S. but relatively high-skill intensive within Mexico—increased as well. The skill premium also increased in both countries.

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1. Introduction

One of the surprising facts about the U.S. and Mexican economies is that, as Table 1 shows, both countries showed a rise in the relative wage of high-skilled to low-skilled workers in manufacturing industries from 1994 to 2000.¹ As can be seen, the skill premium increased from 1.78 to 1.91 in the U.S. manufacturing industry, and it increased from 2.14 to 2.21 in the Mexican manufacturing industry. It should be noted that even after 1994, when the North American Free Trade Agreement (NAFTA) was enacted, the Mexican skill premium slightly increased.²

Table 1 also shows that trade between the U.S. and Mexico increased during the same period. As can be seen, the U.S.-Mexican trade as a percent of U.S. GDP increased from 1.42 percent to 2.52 percent. This U.S.-Mexican trade seems small in volume; however, it is not small from the Mexican viewpoint. In fact, the U.S.-Mexican trade as a fraction of Mexican GDP was 23.85 percent in 1994 and 42.58 percent in 2000 as shown in the table.³

Due to this similarity in the movements of trade and skill premium, we can no longer ignore the possible effect of trade on the recent increase in skill premium in these countries. We thus want to provide a trade-based explanation for the increased skill premium in both countries, which is consistent with available empirical evidence.

At first sight, this seems to pose a serious theoretical challenge to us, for there is a discrepancy between the standard Heckscher-Ohlin (H-O) model and the data throughout the 1994-2000 period. According to the standard static two-good H-O model,

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¹ The average annual wage of non-production relative to production labor is used as an index for the relative wage of high-skilled to low-skilled labor as will be discussed in Section 3-1. We calculate the U.S. and Mexican relative wage on the basis of the U.S. Annual Survey of Manufactures (ASM) and the Mexican Monthly Industrial Survey (Encuesta Industrial Mensual, or EIM), respectively. We also note that trade is the sum of U.S. exports to and U.S. imports from Mexico, and the data are obtained from the International Trade Administration and the Bureau of Economic Analysis.

² As will be shown later, our interest is in a static story, so here we look at a one-time increase in the skill premium comparing the skill premium in 1994 and in 2000. The time-series movements of the skill premium during 1994-2000 are thus outside the scope of this paper. Note, however, that the EIM shows that the non-production/production wage ratio in Mexico increased between 1994 and 1998, and since then, this ratio has become stable. Esquivel and Rodríguez-López (2003) also show the same movements of Mexican wages. It should be noted, however, that Robertson (2004) argues, using the Mexican Industrial Census, that the Mexican skill premium declined from 1994 to 1998.

³ Trade-based explanations for this rising wage inequality have often been criticized due to the small volume of trade. Krugman (1995, 2000) provides a theoretical argument to explain why the small volume of trade in the U.S. makes it unlikely that trade can account for the change in wages.
the high-skill abundant U.S. will export to Mexico high-skill intensive goods, while low-skill abundant Mexico will export to the U.S. low-skill intensive goods. The U.S. exports of high-skill intensive goods to Mexico will increase the output of these goods in the U.S., thus increasing demand for U.S. high-skilled workers and their wages. The Mexican exports of low-skill intensive goods to the U.S., on the other hand, will increase the output of these goods in Mexico, thus increasing demand for Mexican low-skilled workers and their wages. Thus the relative wage of high-skilled to low-skilled workers should increase in the U.S. but decrease in Mexico after trade.

This, however, is merely an apparent theoretical challenge. In fact, the rising skill premium in these two countries can be explained simply by the static two-good H-O model if we assume a “skill intensity reversal.” That is, U.S. exports to Mexico of goods which are relatively high-skill intensive compared to other goods within the U.S. but relatively low-skill intensive within Mexico will increase demand for U.S. high-skilled workers but decrease demand for Mexican low-skilled workers. On the other hand, U.S. imports from Mexico of goods which are relatively low-skill intensive compared to other goods within the U.S. but relatively high-skill intensive within Mexico will decrease demand for U.S. low-skilled workers but increase demand for Mexican high-skilled workers. Thus the relative wage of high-skilled to low-skilled workers will increase in both countries.4

A serious empirical challenge is, however, imposed on us. This is because little

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4 Of course, all industries in the U.S. might use skilled labor more intensively than do the corresponding industries in Mexico, but it is the reversal of relative skill intensities that the H-O theory says can account for the increase in the wage gap in both countries. Thus in the following discussion, the word “skill intensity reversal” refers to the reversal of relative skill intensities between two countries.
evidence for the so-called “factor intensity reversal” has been found in manufacturing industries in past empirical studies (Minhas, 1962; Leontief, 1964; Moroney, 1967).  

Should we thus conclude that a factor intensity reversal is theoretically interesting but empirically unimportant? The answer is no. This is because the so-called factor intensity reversal has so far referred only to a capital/labor intensity reversal. However, our focus is now on a skill intensity reversal. Unfortunately, no serious empirical work on the skill intensity reversal has been done until now although a division of factors by skills has recently become more and more important in international trade theories. Thus it is time to revive the factor-intensity-reversal controversy in the 1960s with the fresh viewpoint of a skill division among labor.

The main purpose of this paper is to demonstrate that there is clear-cut empirical evidence for the existence of the skill intensity reversal and that the static two-good H-O model can be one possible explanation for the increase in the wage gap in both countries from 1994 to 2000. We first show that both the U.S. net exports to Mexico of electronics products and the U.S. net imports from Mexico of non-electronics products significantly increased from 1994 to 2000, and, in fact, it is in 2000 that the electronics industry became the largest U.S. net export industry to Mexico of all manufacturing industries.

We next show that the electronics products were relatively high-skill intensive compared to the non-electronics products within the U.S. but relatively low-skill intensive within Mexico both in 1994 and in 2000. In other words, the non-electronics products were relatively low-skill intensive compared to the electronics products within the U.S. but relatively high-skill intensive within Mexico. Here let us recall that, as Table 1 has shown, the skill premium also increased in both U.S. and Mexican manufacturing industries.

Thus the static two-good H-O story with the reversal of relative skill intensities is compatible with the evidence presented in this paper.

This paper makes two contributions, one empirical and the other theoretical. This paper is the first to exhibit clear-cut evidence for the existence of the skill intensity reversal, thus letting us conclude that the so-called “factor intensity reversal” is not a

5 There is evidence in agricultural production such as maize (corn) production in the U.S. and Mexico (Larudee, 1998). If maize is relatively labor intensive in Mexico but relatively capital intensive in the U.S., Mexican imports of agricultural products such as maize from the U.S. hurt labor in both countries (Larudee, 1998).
mere theoretical curiosum. Moreover, the evidence presented in this paper lets us propose one simple resolution of the discrepancy between the standard H-O model and the data on wage inequality throughout the 1994-2000 period.

The rest of this paper is organized as follows. In Section 2, we show some evidence for U.S.-Mexican trade, thus dividing the manufacturing industries into two groups: the major U.S. net export industry (the electronics industry) and the U.S. net import industry (the non-electronics industry). Section 3 defines skill intensity and shows that each industry exhibited a skill intensity reversal between the U.S. and Mexico. Finally, we summarize main results and mention future research in Section 4.

2. Evidence for U.S.-Mexican Trade

First, let us identify the industry which accounts for the major U.S. net exports to Mexico. It is the electronics industry (2-digit SITC Rev. 3 category 77). Figure 1-A shows the U.S. net exports of the electronics products to Mexico in 1994 and 2000. As can be seen, they remarkably increased from 1994 to 2000. In fact, as shown in Table 2, it is in 2000 that the U.S. electronics industry became the largest net export industry to Mexico of all the 2-digit SITC categories of U.S. manufacturing industries.

Next, let us define all the other 2-digit SITC categories of U.S. manufacturing industries as the non-electronics industry. Figure 1-B shows the U.S. net exports of the non-electronics products to Mexico in 1994 and 2000. As can be seen, they remarkably decreased from 1994 to 2000. In other words, the U.S. net imports of non-electronics products from Mexico significantly increased from 1994 to 2000.

Thus in the following main text, we divide the manufacturing industries into the electronics industry, whose U.S. net exports increased from 1994 to 2000, and the non-electronics industry, whose U.S. net imports increased during the same period. We note that it is this electronics/non-electronics classification that makes the two-good H-O story compatible with the data although the classification seems too broad.6

6 Our purpose is to show evidence compatible with the two-good H-O model, so here we use 2-digit very aggregated data. It would also be interesting to look at very disaggregated data and investigate the skill intensities of various disaggregated goods, although this is outside the scope of this paper.
FIGURE 1-A. U.S. Net Exports of Electronics Products to Mexico, 1994 and 2000

FIGURE 1-B. U.S. Net Exports of Non-Electronics Products to Mexico, 1994 and 2000

TABLE 2
Top 5 U.S. Net Exports to Mexico in Manufacturing Industries, 2000

<table>
<thead>
<tr>
<th>Rank</th>
<th>SITC Code</th>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>77</td>
<td>Electrical Machinery, Apparatus &amp; Appliances</td>
<td>4,764</td>
</tr>
<tr>
<td>2</td>
<td>99</td>
<td>Low Value Shipments</td>
<td>4,446</td>
</tr>
<tr>
<td>3</td>
<td>89</td>
<td>Miscellaneous Manufactured Articles</td>
<td>2,837</td>
</tr>
<tr>
<td>4</td>
<td>65</td>
<td>Textile Yarn, Fabrics</td>
<td>2,254</td>
</tr>
<tr>
<td>5</td>
<td>57</td>
<td>Plastics in Primary Form</td>
<td>2,156</td>
</tr>
</tbody>
</table>

Note: Net exports are in millions of dollar (2000 base year).
Source: The International Trade Administration.
3. Evidence for Skill Intensity Reversal

In this section, we present empirical evidence that there indeed existed the reversal of relative skill intensities between the U.S. and Mexican manufacturing industries.

3.1. Definition of Skill Intensity

Let us define skill intensity for manufacturing industry $i$ by:

$$\frac{\text{NPD}_i}{\text{PD}_i} = \frac{\text{The Number of Non-Production Workers in Industry } i}{\text{The Number of Production Workers in Industry } i}.$$  

Here we have used non-production and production workers as an index for high-skilled and low-skilled workers in the U.S. and Mexican manufacturing industries. This classification is made in the U.S. Annual Survey of Manufactures (ASM) and the Mexican Monthly Industrial Survey (Encuesta Industrial Mensual, or EIM), and it is used as an index for the skill-level for workers in many papers. Feenstra and Hanson (1996), for example, use the classification for both U.S. and Mexican skills as well as does our paper.

We note that using the non-production/production classification as an index for skill has been criticized in U.S. studies (Leamer, 1994). There is, however, evidence for the U.S. which exhibits that the non-production and production classification (as well as the white- and blue-collar classification) works well as a division of the labor force by skill (Berman, Bound, and Griliches, 1994; Berman, Bound, and Machin, 1998; Sachs and Shatz, 1994).

In Mexico, on the other hand, this distinction seems to better capture skill intensity. In fact, Robertson (2004) shows that production workers have less education in every industry than non-production workers and that industries with higher relative employment ratios of non-production to production workers also have higher average education levels. Hanson and Harrison (1999) argue that there are no data for Mexico that provide a more detailed breakdown of employment by skill and by industry.

Thus, using the non-production/production classification to (imperfectly) classify skill intensity seems valid in both the U.S. and Mexico, although further investigation is needed.
3.2. Skill Intensity Reversal between U.S. and Mexico

Figures 2-A and 2-B plot the skill intensity in the U.S. and Mexican manufacturing industries in 1994 and 2000. As in Section 2, we divide the manufacturing industries into the electronics industry and the non-electronics industry. The data for this skill intensity are from the U.S. ASM and the Mexican EIM.7

If an industry in the U.S. and Mexico showed a similarity in relative skill intensity, then the industry’s skill intensity would be located in the first or third quadrants in these figures. That is, this industry would be relatively high-skill intensive compared to the other industry within each country or relatively low-skill intensive within each country.

However, the electronics industry actually exhibited a “skill intensity reversal” both in 1994 and in 2000. As can be seen, the industry’s skill intensity is located in the second quadrant in these figures. That is, this electronics industry was relatively high-skill intensive compared to the non-electronics industry within the U.S. but relatively low-skill intensive within Mexico.

On the other hand, the non-electronics industry also exhibited a skill intensity reversal both in 1994 and in 2000. As can be seen, the industry’s skill intensity is located in the fourth quadrant in these figures. That is, this non-electronics industry was relatively low-skill intensive compared to the electronics industry within the U.S. but relatively high-skill intensive within Mexico.

We have thus seen that a factor intensity reversal—in particular, a skill intensity reversal—is no longer a mere theoretical curiosum.8

It is highly likely that outsourcing by the U.S. electronics product industry—in particular, overseas assembly—has been making a substantial contribution to this skill intensity reversal. By overseas assembly we mean that U.S. firms export component parts, have them assembled overseas, and import back the finished products into the U.S.

This overseas assembly encourages the U.S. firms to specialize in high-skill intensive

7 Here we define the 2-digit SIC 1987 category 36 (Electronic and Other Electric Equipment) and the 3-digit ISIC Rev. 2 category 383 (Machinery, Electric) as the U.S. and Mexican electronics industries, respectively. These are approximately corresponding to the 2-digit SITC Rev. 3 category 77 (Electrical Machinery, Apparatus and Appliances). Haveman's Industry Concordances (http://www.macalester.edu/research/economics/PAGE/HAVEMAN/Trade.Resources/TradeConcordances.html), now maintained by Robertson, provides many correspondence tables between the major classification systems.

8 It can be shown that the skill intensity for the electronics product industry was located in the first quadrant in 1987, indicating that this industry was relatively high-skill intensive within each country. There was no skill intensity reversal in the late 1980s.
FIGURE 2-A. Skill Intensity in U.S. and Mexican Manufactures, 1994

FIGURE 2-B. Skill Intensity in U.S. and Mexican Manufactures, 2000

*Note:* Broken lines represent the averages of skill intensity within each country. Note also that these two figures use different scales, for here we want to emphasize the relative relationship between the skill intensities of the two industries which determines a comparative advantage in the H-O model. The absolute values of the skill intensities are not of interest in this paper. 

*Source:* Author’s calculations based on the ASM and the EIM.
operations, and it encourages Mexican plants such as *maquiladora* plants to specialize in low-skill intensive operations.\(^9\)

### 4. Conclusion and Future Research

In Sections 2 and 3, we have shown that the U.S. net exports to Mexico of electronics products, which were relatively high-skill intensive within the U.S. but relatively low-skill intensive within Mexico, significantly increased from 1994 to 2000. We have also shown that the U.S. net imports from Mexico of non-electronics products, which were relatively low-skill intensive within the U.S. but relatively high-skill intensive within Mexico, significantly increased during the same period. Here let us recall that the skill premium also increased in both U.S. and Mexican manufacturing industries.

It has been said that a factor intensity reversal is a mere theoretical curiosum and thus of no empirical importance. However, we can now say with confidence that a factor intensity reversal—in particular, a skill intensity reversal—exists. We thus conclude that the static two-good H-O story with the reversal of relative skill intensities is compatible with the evidence presented above.

Of course, room for future research still exists. First, a skill intensity reversal is theoretically possible only when isoquant curves of factor-price frontiers of export and import sectors have more than one intersection. This in turn depends on whether these two sectors have different elasticities of substitution between skills. Since we have presented in this paper solid empirical evidence that the skill intensity reversal actually exists, our next logical step is to return to the fundamentals—to investigate the technological structures of the U.S. and Mexico and estimate their elasticities of substitution between skills.

Second, this paper has been focusing on the problems of trade between the U.S. and Mexico, but it would be also possible to directly apply our discussion to the problems of trade between Canada and Mexico. This is because there would be smaller differences in factor proportions between Canada and the U.S. than between the U.S. and Mexico.

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\(^9\) It should be noted that U.S. firms received favorable tariff treatment through the Offshore Assembly Program (OAP) which is known as the 9802 program. According to Feenstra, Hanson, and Swenson (2000), virtually all of the *maquiladora* plants in Mexico were engaged in assembly of parts under the OAP program. However, with the implementation of the NAFTA, products no longer need this OAP program to receive favorable tariff treatment, although the overseas assembly may continue.
Finally, this paper has been focusing on the discrepancy between the standard H-O model and the data after the NAFTA, showing one possible resolution on the basis of a skill intensity reversal. Note, however, that the skill premium in the U.S. and Mexico actually began to rise in the late 1980s, when we could not observe any clear-cut skill intensity reversal. Dinopoulos and Segerstrom (1999), for example, have successfully eliminated the discrepancy between the model and the data before the NAFTA without assuming this skill intensity reversal.\footnote{Some papers also provide a non H-O based explanation for the rise in skill premium in two countries. See also Feenstra and Hanson (1996), Acemoglu (2003), Xu (2003), Zhu and Trefler (2005), and Kurokawa (2007).} They show that trade increases the relative price of innovation (the reward for innovation relative to the current level of R&D difficulty), thus encouraging high-skill intensive R&D investment in each country. They also show that a contemporaneous correlation between an index of the relative price of innovation and an index of the U.S. skill premium was 0.80 during the period 1963-1989. The next step is, thus, to connect these pre- and post-NAFTA studies.
References


