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Kurokawa, Yoshinori

University of Minnesota

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Skill Intensity Reversal and the Rising Skill Premium: Evidence from the U.S. and Mexico

Yoshinori Kurokawa*

Department of Economics, University of Minnesota

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Abstract

Rising skill premium in two countries can be explained simply 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, which were *high-skill* intensive in the U.S. but *low-skill* intensive in Mexico, increased from 1994 to 2000. U.S. *net imports* from Mexico of non-electronics products, which were *low-skill* intensive in the U.S. but *high-skill* intensive in Mexico, increased as well. The skill premium then increased in *both* countries.

Keywords: Heckscher-Ohlin model; Skill intensity reversal; Rising skill premium; U.S.; Mexico

JEL classification: F11; F14; F16

* Department of Economics, University of Minnesota, Minneapolis, MN 55455; Tel.: +1-612-626-9248; Fax: +1-612-624-0209; E-mail address: kyoshi@econ.umn.edu. I am very grateful to my advisor Tim Kehoe for his helpful suggestions and guidance and to Professors Cristina Arellano, Michele Boldrin, and Terry Roe for their comments. I wish to thank Professors Michihiro Ohyama, Katsuhito Iwai, and Yoshimasa Shirai for their comments and encouragement. I also thank Kim Strain, Kirsten Jansen, and Andrew Cassey for their careful correction of my English. However, the remaining errors are exclusively mine.

1. Introduction

One of the surprising facts about the U.S. and Mexican economies is that, as Fig. 1 shows, both countries showed a rising trend of the relative wage of high-skilled to low-skilled workers in manufacturing industries during 1990-2000.¹ As can be seen, even after 1994, when the North American Free Trade Agreement (NAFTA) was enacted, the Mexican skill premium was actually increasing or stable along with the rise in the U.S. skill premium.²

Data shows also that the movements of trade between the U.S. and Mexico were surprisingly similar to the movements of skill premium during the same period, 1990-2000. That is, the trade between these two countries has also shown a rising trend during this period as shown in Fig. 2.³

Due to this similarity in the movements of trade and skill premium, we can no longer ignore the effect of trade on the recent increase in skill premium in wages. At first sight, this seems to pose a serious theoretical challenge to us, for there is a discrepancy between the standard H-O (Heckscher-Ohlin) model and the data during the 1990s.

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. We calculated 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 (EIM), respectively.

² Esquivel and Rodríguez-López (2003) also show that the non-production/production wage ratio in Mexico increased from 1988 to 1996, and since then this ratio became stable. Note, however, that Robertson (2004) argues 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.

According to the standard H-O model, the high-skill abundant U.S. will export to Mexico high-skill intensive goods, while the 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, rising skill premium in these two countries can be explained simply by the H-O model if we assume a “skill intensity reversal.” That is, U.S. *exports* to Mexico of goods which are *high-skill* intensive in the U.S. but *low-skill* intensive in 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 *low-skill* intensive in the U.S. but *high-skill* intensive in 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.

A serious *empirical* challenge is, however, imposed on us. This is because little evidence for the so-called “factor intensity reversal” has been found in manufacturing industries in past empirical studies (Minhas, 1962; Leontief, 1964; Moroney, 1967).⁴

⁴ There is evidence in agricultural production such as maize (corn) production in the U.S. and Mexico (Larudee, 1998). If maize is labor intensive in Mexico but 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).

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 skill intensity reversal. 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, 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 *high-skill* intensive in the U.S. but *low-skill* intensive in Mexico both in 1994 and in 2000, and that the non-electronics products were *low-skill* intensive in the U.S. but *high-skill* intensive in Mexico.

Thus the evidence presented above supports our hypothesis that one of the major causes for the rising skill premium in the U.S. and Mexican manufacturing industries from 1994 to 2000 is a skill intensity reversal.

The rest of this paper is organized as follows. In Section 2, we show some evidence for trade between the U.S. and Mexico, 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. Section 4 shows evidence for the rising skill premium in each country. Finally, we summarize main results and mention future research in Section 5.

2. Evidence for Trade between U.S. and Mexico

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). Fig. 3a 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 1, 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. Fig. 3b 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.

3. Evidence for Skill Intensity Reversal

In this Section, we present empirical evidence that there indeed existed a skill intensity reversal between the U.S. and Mexican manufacturing industries.

3.1. Definition of Skill Intensity

Let us define skill intensity for manufacturing industry i by:

$$\frac{NPD_i}{PD_i} = \frac{\text{The Number of Non - Production Workers in Industry } i}{\text{The Number of Production Workers in Industry } i}$$

We have here used non-production and production workers as an index for high-skilled and low-skilled workers in the U.S. and Mexican manufacturing industries. We follow Berman, Bound, and Griliches (1994) who exhibit 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.

3.2. Skill Intensity Reversal between U.S. and Mexico

Fig. 4a and 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 is from the U.S. Annual Survey of Manufactures (ASM) and the Mexican Monthly Industrial Survey (EIM).⁵

If an industry in the U.S. and Mexico showed a similarity in skill intensity, its skill intensity would be located in the first or third quadrants in these figures. That is, this industry would be relatively high-skill intensive in both countries or relatively low-skill intensive in both countries.

However, the electronics industry actually exhibited a “skill intensity reversal” both in 1994 and in 2000. As can be seen, its skill intensity is located in the second quadrant

⁵ We here 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.

in these figures. That is, this electronics industry was relatively *high-skill* intensive in the U.S. but relatively *low-skill* intensive in 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, its skill intensity is located in the fourth quadrant in these figures. That is, this non-electronics industry was relatively *low-skill* intensive in the U.S. but relatively *high-skill* intensive in Mexico.

We have thus seen that a factor intensity reversal—in particular, a skill intensity reversal—is no longer a mere theoretical curiosity.⁶

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 operations, and it encourages Mexican plants such as *maquiladora* plants to specialize in low-skill intensive operations.⁷

4. Evidence for Skill Premium

The purpose of this section is to show that the relative wage of high-skilled to low-skilled workers actually *increased* in *both* U.S. and Mexican manufacturing

⁶ 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 high-skill intensive in both countries. There was no skill intensity reversal in the late 1980s.

⁷ 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 et al. (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.

industries from 1994 to 2000.

Table 2 is an extract from Fig. 1, and this table shows the skill premium in the U.S. and Mexican manufacturing industries in 1994 and 2000. 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.

5. Conclusion and Future Research

In Sections 2 and 3, we have shown that U.S. *net exports* to Mexico of electronics products, which were *high-skill* intensive in the U.S. but *low-skill* intensive in Mexico, significantly increased from 1994 to 2000. We have also shown that U.S. *net imports* from Mexico of non-electronics products, which were *low-skill* intensive in the U.S. but *high-skill* intensive in Mexico, significantly increased during the same period. Finally, Section 4 has shown that the skill premium *increased* in *both* U.S. and Mexican manufacturing industries during the same period.

All the evidence presented above supports our hypothesis that one of the major causes for the rising skill premium in the U.S. and Mexican manufacturing industries from 1994 to 2000 is a skill intensity reversal.

It has been said that a factor intensity reversal is theoretically interesting but of no empirical importance. However, we can now say with confidence that a factor intensity reversal—in particular, a skill intensity reversal—exists.

Of course, there is still room for future research. First, whether a skill intensity reversal is theoretically possible or not relies on whether iso-quant curves or factor-price frontiers have only one intersection or more. In other words, it depends on whether the elasticities of substitution between skills are equal in all sectors or not. This paper has

shown that the skill intensity reversal actually existed, so we need to empirically investigate the elasticities of substitution between skills.

Second, this paper has been focusing on the discrepancy between the standard H-O model and the data during the 1990s, 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 during the 1980s, when we could not observe any clear-cut skill intensity reversal. Kurokawa (2006) has successfully eliminated the discrepancy between the model and the data during the 1980s without assuming this skill intensity reversal.⁸ He shows that intra-industry trade increases the variety of intermediate goods used by a high-skill intensive final good, and, therefore, a skill premium rises in both countries if the varieties and high skill are “complements.” He also shows that the correlation between the U.S.-Mexican intra-industry trade and the skill premium was high in each country during the 1980s. Our next step is, thus, to connect these two studies.

⁸ Dinopoulos and Segerstrom (1999) are also successful in eliminating the discrepancy between the model and the data during the 1980s. They show that trade encourages R & D investment, resulting in innovation and skill-biased technological change 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.

References

- Acemoglu, D., 1999.** Patterns of Skill Premia. National Bureau of Economic Research, Inc., NBER Working Papers 7018.
- Berman, E., Bound, J., Griliches, Z., 1994.** Changes in the Demand for Skilled Labor within U.S. Manufacturing: Evidence from the Annual Survey of Manufactures. *Quarterly Journal of Economics* 109, 367-397.
- Dinopoulos, E., Segerstrom, P., 1999.** A Schumpeterian Model of Protection and Relative Wages. *American Economic Review* 89, 450-473.
- Esquivel, G., Rodríguez-López, J.A., 2004.** Technology, Trade, and Wage Inequality in Mexico before and after NAFTA. *Journal of Development Economics* 75, 79-94.
- Feenstra, R.C., Hanson, G.H., 1996.** Foreign Investment, Outsourcing and Relative Wages. In: Feenstra, R.C., Grossman, G.M., Irwin, D.A. (Eds.), *The Political Economy of Trade Policy: Papers in Honor of Jagdish Bhagwati*. MIT Press, Cambridge, MA, pp. 89-127.
- Feenstra, R.C., Hanson, G.H., 2003.** Global Production Sharing and Rising Inequality: A Survey of Trade and Wages. In: Choi, K., Harrigan, J. (Eds.), *Handbook of International Trade*. Basil Blackwell, Oxford, pp. 146-187.
- Feenstra, R.C., Hanson, G.H., Swenson, D.L., 2000.** Offshore Assembly from the United States: Production Characteristics of the 9802 Program. In: Feenstra, R.C. (Ed.), *The Impact of International Trade on Wage*. University of Chicago Press, Chicago, IL, pp. 85-122.
- Hanson, G.H., Harrison, A., 1995.** Trade, Technology, and Wage Inequality. National Bureau of Economic Research, Inc., NBER Working Papers 5110.
- Katz, L.F., Autor, D.H., 1999.** Change in the Wage Structure and Earnings Inequality.

- In: Ashtenfelder, O., Card, D. (Eds.), *Handbook of Labor Economics*, Vol. 3A. North-Holland, Amsterdam, pp. 1463-1555.
- Krugman, P.R., 1995.** Growing World Trade: Causes and Consequences. *Brooking Paper on Economic Activity* 1995, 327-362.
- Krugman, P.R., 2000.** Technology, Trade and Factor Prices. *Journal of International Economics* 50, 51-72.
- Krusell, P., Ohanian, L.E., Rios-Rull, J.V., Violante, G.L., 2000.** Capital-Skill Complementarity and Inequality: A Macroeconomic Analysis. *Econometrica* 68, 129-154.
- Kurokawa, Y., 2006.** Trade and Variety-Skill Complementarity: A Simple Trade-Based Resolution of Wage Inequality Anomaly. Mimeo, University of Minnesota.
- Larudee, M., 1998.** Integration and Income Distribution under the North American Free Trade Agreement: The Experience of Mexico. In: Baker, D., Epstein, G., Pollin, R. (Eds.), *Globalization and Progressive Economic Policy*. Cambridge University Press, Cambridge, UK, pp. 273-295.
- Lawrence, R., Slaughter, M.J., 1993.** International Trade and American Wages in the 1980s: Giant Sucking Sound or Small Hiccup? *Brookings Papers on Economic Activity: Microeconomics* 1993, 161-226.
- Leontief, W., 1964.** An International Comparison of Factor Costs and Factor Use: A Review Article. *American Economic Review* 54, 335-345.
- Minhas, B.S., 1962.** The Homohypallagic Production Function, Factor Intensity Reversals and the Heckscher-Ohlin Theorem. *Journal of Political Economy* 70, 138-156.

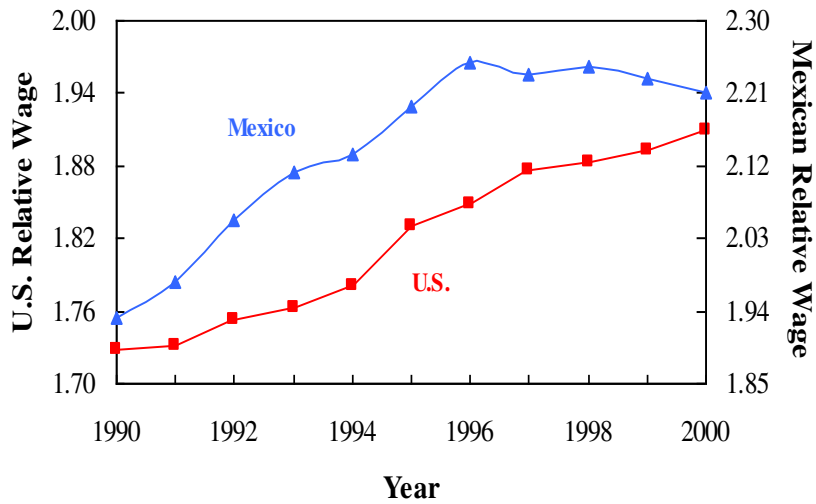
Moroney, J.R., 1967. The Strong-Factor-Intensity Hypothesis: A Multisectoral Test.

Journal of Political Economy 75, 241-249.

Robertson, R., 2004. Relative Prices and Wage Inequality: Evidence from Mexico.

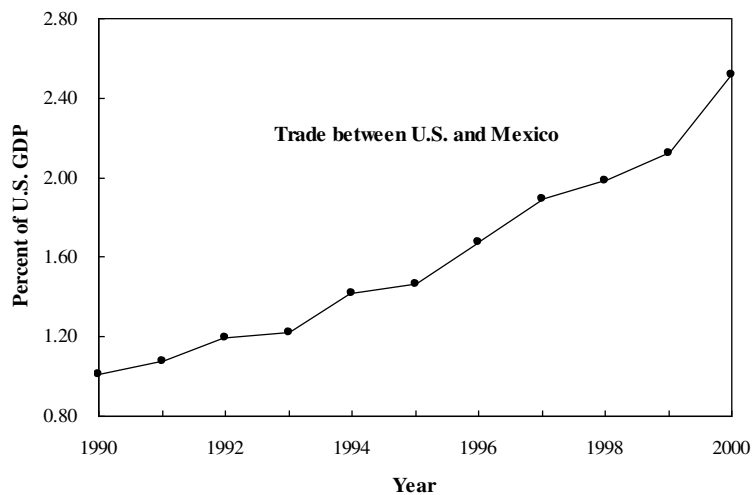
Journal of International Economics 64, 387-409.

Fig. 1. Relative Wage of High-Skilled to Low-Skilled Labor in U.S. and Mexican Manufacturing Industries: 1990-2000



Source: Author's calculations based on the ASM and the EIM.

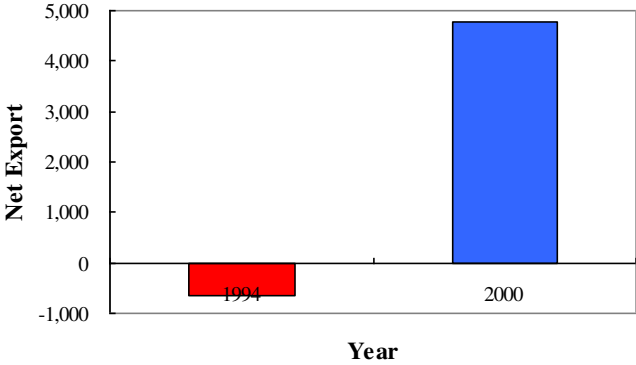
Fig. 2. Trade between U.S. and Mexico as Percent of U.S. GDP: 1990-2000



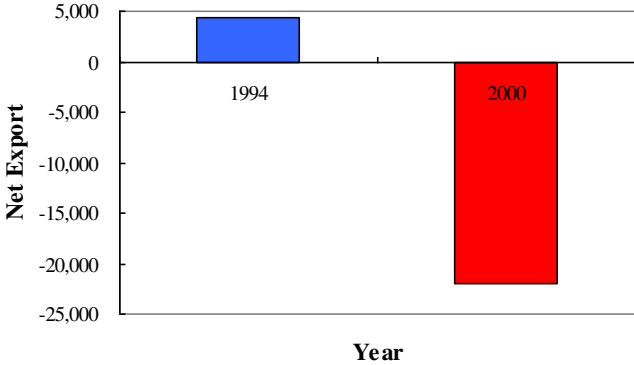
Note: Trade is the sum of U.S. exports to and U.S. imports from Mexico.

Source: Author's calculations based on the International Trade Administration and the Bureau of Economic Analysis.

**Fig. 3. (a) U.S. Net Exports of Electronics Products to Mexico:
1994 and 2000**



**Fig. 3. (b) U.S. Net Exports of Non-Electronics Products to Mexico:
1994 and 2000**



**Table 1. Top 5 U.S. Net Exports to Mexico in Manufacturing
Industries: 2000**

Rank	SITC Code	Description	Amount
1	77	Electrical Machinery, Apparatus & Appliances	4,764
2	99	Low Value Shipments	4,446
3	89	Miscellaneous Manufactured Articles	2,837
4	65	Textile Yarn, Fabrics	2,254
5	57	Plastics in Primary Form	2,156

Note: The values of net exports are in millions of dollar.

Source: The International Trade Administration.

Fig. 4. (a) Skill Intensity in U.S. and Mexican Manufactures: 1994

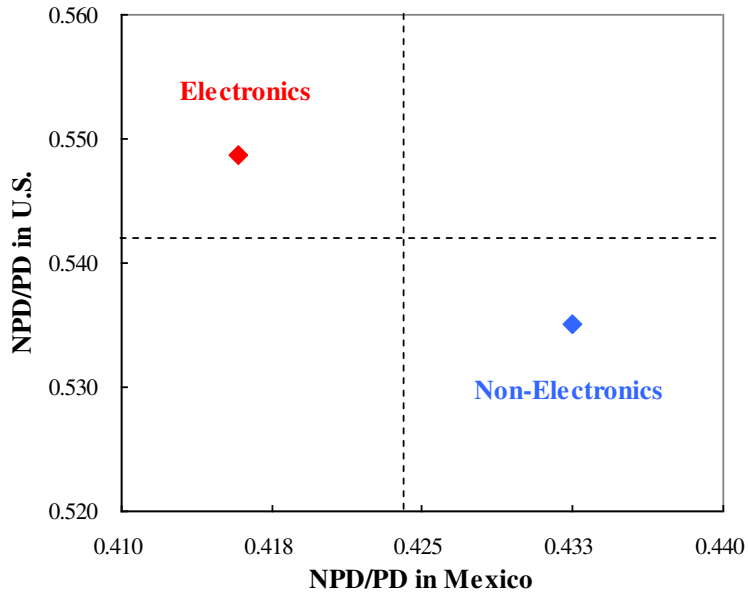
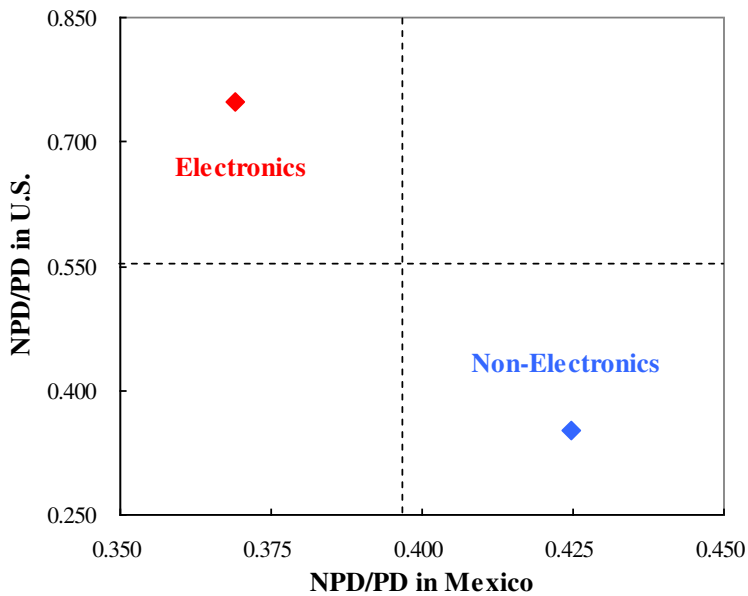


Fig. 4. (b) Skill Intensity in U.S. and Mexican Manufactures: 2000



Note: Broken lines represent the averages of skill intensity within each country.

Source: Author's calculations based on the ASM and the EIM.

Table 2. Skill Premium in U.S. and Mexican Manufacturing

Industries: 1994 and 2000

	U.S.	Mexico
1994	1.78	2.14
2000	1.91	2.21

Source: Author's calculations based on the ASM and the EIM.