

Cheung, Yin-Wong; Fujii, Eiji

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## The Penn effect within a country: Evidence from Japan

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The Penn Effect within a Country –  
Evidence from Japan

Yin-Wong Cheung  
Eiji Fujii

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# The Penn Effect within a Country – Evidence from Japan

## Abstract

To control for product quality and eliminate the exchange rate volatility effect, we use the Japanese regional data to study the Penn effect – the positive relationship between price and income levels. Similarly to what is widely documented with international data, the price and income levels exhibit significant positive association across the Japanese prefectures. Furthermore, the intra-Japan Penn effect is driven essentially by prices of nontradables. The effect is also found stronger among rich prefectures than poor ones, as is the case with the international data. In explaining the Penn effect within Japan, we find that the measures of sectoral productivity do not behave in the way suggested by the Balassa-Samuelson hypothesis. On the other hand, the population density variable that captures the agglomeration effect offers a good explanatory power.

JEL-Code: F310, F340, F360.

Keywords: agglomeration effect, Penn effect, sectoral productivity differential, tradables and non-tradables, population density.

*Yin-Wong Cheung*  
*Department of Economic and Finance*  
*City University of Hong Kong*  
*Hong Kong*  
*yicheung@cityu.edu.hk*

*Eiji Fujii*  
*School of Economics*  
*Kwansei Gakuin University*  
*Hyogo / Japan*  
*efujii@kwansei.ac.jp*

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## 1. Introduction

The Penn effect refers to the robust empirical positive association between national price levels and real *per capita* incomes that is documented by a series of Penn studies including Kravis and Lipsey (1983, 1987), Kravis, Heston and Summers (1978), and Summers and Heston (1991). That is, compared with poor countries, rich countries tend to have higher price levels. The positive association between income and price levels is considered as a fundamental fact of economics (Samuelson, 1994) and a conventional wisdom in international macroeconomics (Bergin 2009).

Since the early Penn studies, the internationally comparable income and output data derived from surveys conducted by the International Comparison Program (ICP) have been commonly used to analyze the price-income relationship. The reliability of ICP-based data, however, is under scrutiny with the release of price and output data derived from the 2005 ICP survey. One often cited observation is that data revision following the 2005 ICP survey could lead to a substantial modification of national GDP figures – for example, the Chinese and Indian 2005 *per capita* GDPs are, respectively, 39% and 38% smaller than previously estimated (World Bank, 2008). The data revision is also found to induce substantial changes in, say, growth rate estimates, growth determinants, poverty measures, and inequality assessment.<sup>1</sup> For the empirical Penn effect, Cheung, Chinn, and Fujii (2009) illustrate that, although the positive price-income relation survives the data revision, the estimated income effect on prices is discernibly changed.

The sensitivity of empirical results reflects some issues underlying the ICP-based data. Despite its objective of making national price data comparable, it is acknowledged that the ICP-based data are far from perfect for making cross-country comparison (Deaton and Heston, 2010). Several factors contribute to the difficulty of constructing internationally comparable data. For instance, national price level comparison becomes quite tricky, if not infeasible, for countries with different output structures and consumption patterns. These differences are not uncommon between countries at different stages of development and with different cultural backgrounds. Even for a given product, a meaningful comparison of its prices in different countries has to control for its quality attributes; actual or perceived. Apparently, the job of quantifying quality differentials for nontradables is harder to undertake

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<sup>1</sup> See, for example, Ciccone and Jarocinski (2010), Johnson et al. (2009), Ponomareva and Katayama (2010), Chen and Ravallion (2010a, 2010b), and Milanovic (2009).

than for tradables. At this point, it is worth noting that an eminent theoretical explanation of the Penn effect relies on the dichotomy of tradables and nontradables in their price behavior.

The current exercise investigates the price and income relationship using intra-Japan data. The restrictions on trade and labor mobility between countries are quite different from those between regions in Japan. Thus, it will be of interest to investigate if the Penn effect usually documented within the international context could be extended to data within a country.

Beside an alternative perspective, the use of Japanese data alleviates some concerns about data incompatibility and its implications for studying the income effect on prices. For instance, the Japanese regional price data examined in the following sections are for products that are quite similar in both quality and quantity and collected in a unified manner. The income data are compiled using same accounting and tax systems. While it is not true that different regions of Japan consume an identical consumption bundle, the degree of consumption homogeneity within Japan is arguably higher than the one faced by most cross-country analyses. In addition, the intra-Japanese comparison is not subject to the exchange rate volatility effect that inflicts cross-country comparison exercise.

To anticipate the results, we find that the price and income levels are significantly positively associated with each other across the regions in Japan. That is, the Penn effect, commonly documented with international data, is also a staple feature of the intra-Japanese data. The intra-national Penn effect is quite comparable to the international one. For instance, the income effect on prices is stronger among more affluent regions in Japan, as it is among more affluent countries.

Our attempts to explain the intra-Japan price-income relationship offer some mixed results. First, as implied by the usual Balassa-Samuelson argument, the positive price-income association is driven essentially by prices of nontradables rather than those of tradables. However, when assessing the roles of productivities of different sectors between regions, we find that a region with a higher productivity in the *services* sector, rather than in the tradable sector, tends to have a higher relative nontradable-tradable price. Specifically, the proxy for the productivity of the nontradable sector tends to yield a coefficient estimate with a sign different from the one prescribed by the Balassa-Samuelson hypothesis.

The urban agglomeration effect, which is a relatively under-exploited explanation of the Penn effect, appears to gain some support from the Japanese data. The population density variable, used as a proxy for the agglomeration effect, is found to be a significant factor explaining the observed regional price differentials. The marginal explanatory power of the

population density variable is quite high. Nevertheless, the income effect remains significant in the presence of the agglomeration effect variable.

The remainder of this paper is organized as follows. Section 2 provides a brief background discussion, describes the data, and defines the empirical variables. Section 3 estimates the price-income relationship between the Japanese prefectures. The results are then compared to those obtained from international data. Section 4 investigates the implications of tradability and productivity differential for the Japanese price-income relationship using disaggregated data. In section 5, we evaluate the role of the agglomeration effect often highlighted in urban and regional economics in explaining the price-income relationship within Japan. Some concluding remarks are offered in Section 6.

## 2. Preliminaries

### 2.1 Aggregate Price level

At the risk of over-simplification, suppose region  $j$ 's aggregate price level in period  $t$ , in log, is given by

$$p_{j,t} = \alpha p_{N,j,t} + (1-\alpha) p_{T,j,t}, \quad (1)$$

where  $p_{N,j,t}$  is the price of non-tradables,  $p_{T,j,t}$  is the price of tradables, and  $\alpha$  defines the weights of the price components. Similarly, the logged aggregate price level of region  $j^*$  is

$$p_{j^*,t} = \alpha^* p_{N,j^*,t} + (1-\alpha^*) p_{T,j^*,t}. \quad (2)$$

To facilitate comparison, we have to convert the two prices  $p_{j,t}$  and  $p_{j^*,t}$  to the same unit using the exchange rate of the two regions' currencies. Since the relevant exchange rate for regions within Japan is unity,  $p_{j,t}$  and  $p_{j^*,t}$  can be directly compared in the current study.

Two additional assumptions commonly imposed are a) the two price indexes use the same weight; that is,  $\alpha = \alpha^*$ , and b) the prices of tradables are the same across different regions; that is,  $p_{T,j,t} = p_{T,j^*,t}$ . Under these assumptions and the conventional sectoral productivity differential argument, a less productive and, hence, lower income region will have a lower price of nontradables and a lower aggregate price level.

The simple setting outlined above highlights a few controversial issues encountered by cross-country price comparison. Aside from exchange rate volatility, the ability to compare prices is impeded by the facts that aggregate price levels are not necessarily compiled using an identical methodology and that prices of tradables are not necessarily the same across countries. To further complicate the situation, national aggregate price levels

comprise prices of individual products that have heterogeneous, rather than homogeneous, qualities across countries. The quality difference does not only create a wedge between prices of nontradables but also between prices of tradables (Imbs, Mumatz, Ravn and Rey, 2010).

## 2.2 *Price Data*

A region in our exercise is a prefecture in Japan. We use aggregate price levels of forty-seven prefectures in Japan. The Japanese prefectures are geographically defined administrative units largely corresponding to, say, the States in the US. Specifically, we use the Regional Difference Index of Consumer Prices (RDICP) provided by the Statistical Bureau of the Ministry of Internal Affairs and Communications. The sources of the price and other variables used in the following empirical exercise are listed in the Appendix. Instead of absolute price levels, these RDICP series report prefectural consumer price levels relative to the price level of the Tokyo central area comprising twenty-three districts of the Tokyo prefecture. With central Tokyo as the common reference, the RDICP data allow us to gauge the price differentials of these forty-seven Japanese prefectures.

The RDICP series are derived from the price information collected by the Statistical Bureau's retail price survey. The survey records retail prices of products and services that are quite precisely defined. Examples of product and service descriptions include "hen eggs (color: white, size L, sold in pack of 10)," "men's undershirt (short sleeves, knitted, white, 100% cotton, [size] around the chest 88-96cm/MA (M), white, ordinary quality, excluding specially processed goods)," and "permanent wave charges (including shampoo, cut, blow or set) for short hair." In many categories, product brands are specified to ensure that prices are recorded for identical products. For instance, ice cream prices are surveyed specifically for "Häagen-Dazs vanilla (by Häagen-Dazs Japan), 120ml". The specificity of product definition enhances price comparability and minimizes the role of product heterogeneity in explaining price differentials across prefectures.<sup>2</sup>

It is noted that the consumption tax is completely harmonized across all regions in Japan. The consumption pattern across these Japanese prefectures is arguably more homogeneous than the one faced by most cross-country studies. Thus, the prefectural price differentials are less subject to the effects of differential taxes and dis-similar consumption patterns.

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<sup>2</sup> However, the perception of heterogeneity may be induced by factors not controlled for in the survey including the characteristics of the store in which the products are sold.

In sum, the use of these Japanese price data alleviates some of the measurement and data incompatibility issues raised in the previous subsection.

### 2.3 Basic Empirical Variables

The price variable used in the empirical analysis is the deviation from the prefectural average. Specifically, a prefecture's aggregate price level relative to the average of prefecture price levels, in logs, is given by

$$p_{j,t} = \ln P_{j,t} - \sum_{j=1}^{47} \ln P_{j,t} / 47, \quad (3)$$

where  $P_{j,t}$  is prefecture  $j$ 's RDICP in period  $t$ . A similar normalization procedure is also applied to the *per capita* income data derived from information on real gross prefectural income and prefectural population provided by the Statistical Bureau. The prefectural real *per capita* income relative to the average of prefecture figures, in logs, is thus given by

$$y_{j,t} = \ln(Y_{j,t} / H_{j,t}) - \sum_{j=1}^{47} \ln(Y_{j,t} / H_{j,t}) / 47, \quad (4)$$

where  $Y_{j,t}$  and  $H_{j,t}$  denote the real gross prefecture income (RGPI) and population of prefecture  $j$  in period  $t$ , respectively.<sup>3</sup> The RGPI includes net factor payment from other prefectures.

Due to data availability, annual data from 1996 and 2008 are considered. The time averages of  $p_{j,t}$  and  $y_{j,t}$  are listed in Table A.1 of the Appendix. The relative aggregate price level ranges from about five percentage points (-0.049, Okinawa) below to more than eight percents (0.085, Tokyo) above the average. Inter-prefectural *per capita* income differentials are far more substantial. As shown in the far right column of Table A.1, the time-average of *per capita* income relative to the average ranges from -0.29 (Okinawa) to 0.50 (Tokyo). The income variation helps identify the income effect on prices.

## 3. The Penn Effect within Japan

### 3.1 The Canonical Bivariate Regression

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<sup>3</sup> The output and population data are available for the Tokyo prefecture but not for the Tokyo central area. In addition to the twenty-three districts in the center, the Tokyo prefecture includes twenty-six cities, five towns, and eight villages. The RDICP uses the Tokyo central area as the benchmark. The normalization procedure adopted by (3) and (4) ensures the price and output data are comparable.

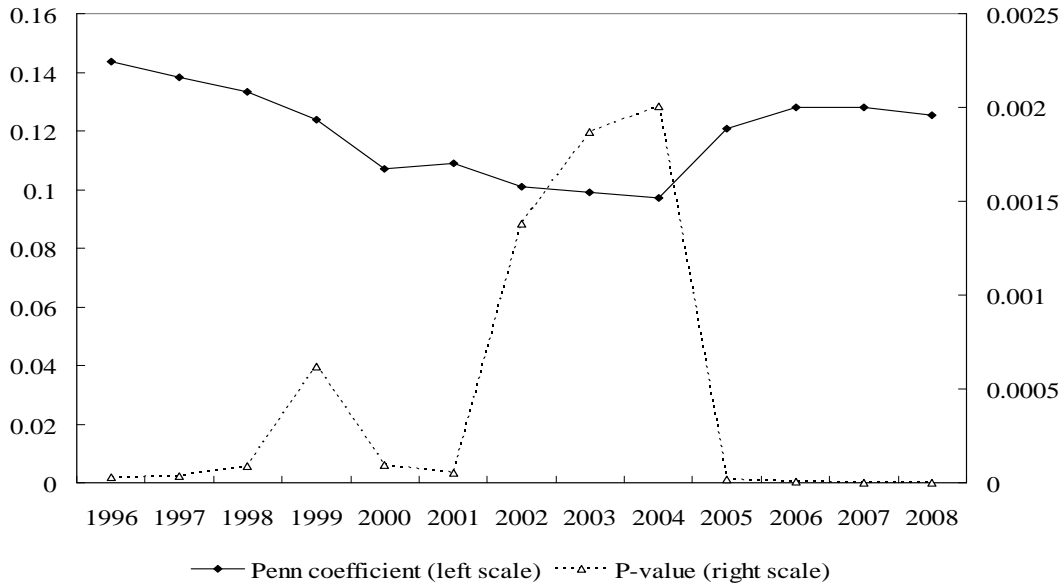


For each year, the Penn effect within Japan is studied using the canonical cross-sectional bivariate specification

$$p_j = \mu + \lambda y_j + \varepsilon_j. \tag{5}$$

Time-subscripts are omitted for brevity henceforth. The time profile of the slope coefficient estimate  $\hat{\lambda}$  and its  $p$ -value obtained from year-by-year cross-sectional regression is depicted in Figure 1.<sup>4</sup> The estimated effect of income on price is significantly positive throughout the sample period. Even though the year-by-year estimates display some variation, the parameter stability tests indicate that these estimates are not statistically different from each other. The Penn effect is a robust empirical feature of the Japanese data.

**Figure 1. Time profile of the Penn effect within Japan**



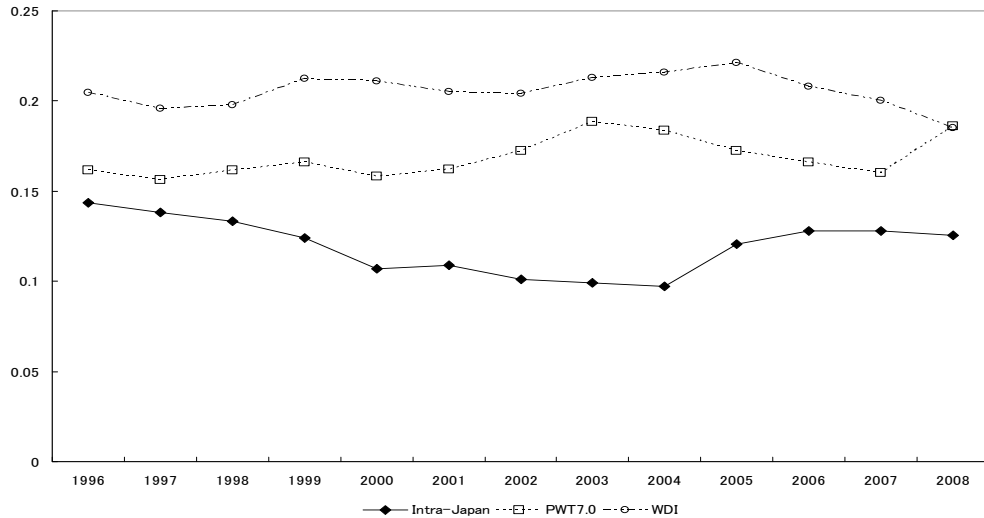
Notes: The figure plots the Penn effect coefficient estimates and their  $p$ -values of the Japanese data obtained from (5) in the main text.

How does the Penn effect within Japan compare to the one documented using international data? Figure 2 plots the year-by-year income effect estimates,  $\hat{\lambda}$ s, obtained from the corresponding data downloaded from the Penn World Table (version 7.0) and the World Development Indicator (January 2012), together with those from the Japanese data. The regressions based on international data used the US as the reference country, and

<sup>4</sup> Since both the dependent and independent variables are deviations from the respective sample averages, the intercept  $\mu$  is zero by construction. Thus, the constant estimates in this study are always insignificantly different from zero and not reported for brevity.

included all countries with available observations. Although both PWT and WDI are derived from the same ICP 2005 survey information, they adopt different approaches in their data compilation methods. Thus, the estimates,  $\hat{\lambda}$  s, from these internationally comparable data are not the same.

**Figure 2. The international and within Japan Penn effects**



Notes: The figure plots the Penn effect coefficient estimates and their p-values of a) the international PWT7.0 and WDI (January 2012) data and b) the Japanese data obtained from (5) in the main text.

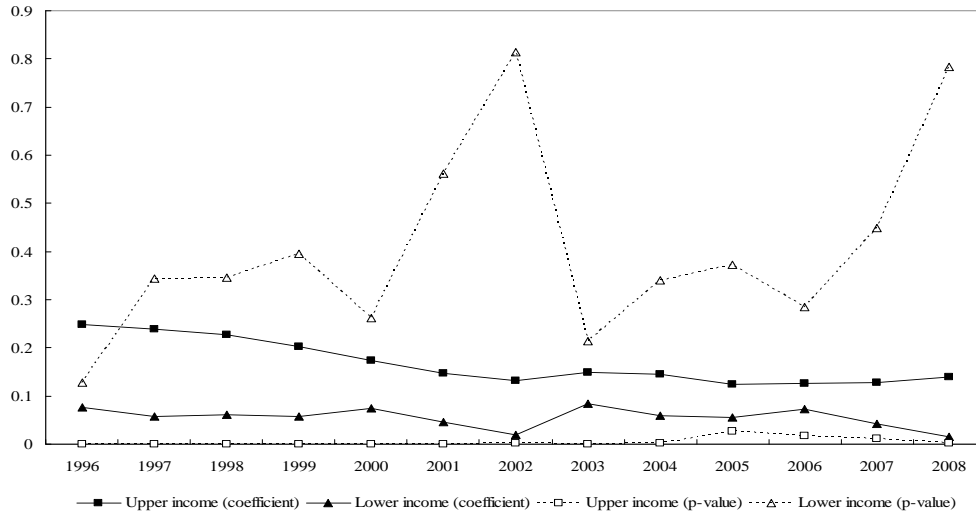
In line with the extant literature, the Penn effect is identified in these two international datasets. The Penn effect displayed by these international data is stronger than the one within Japan; that is, compared with cross-country behavior the change in the income within Japan tends to induce a smaller change in the price level. Further, the evolution of the Japanese  $\hat{\lambda}$  estimates is discernibly different from those of the other two  $\hat{\lambda}$ -estimate series. Aside from these, however, the three datasets exhibit significant positive income effects on price levels, which is a defining signature of the empirical Penn effect. In sum, despite the difference in data compilation and construction methods, the empirical Penn effect appears a pervasive phenomenon in both cross-country and within Japan data.

The results thus far indicate that aggregate price and income levels of Japanese prefectures are positively related to each other in a synonymous fashion with the well-known price-income relationship in the international data. The Penn effect in Japan is qualitative similar though not quantitatively identical to the international Penn effect.

### 3.2 Income level

Some studies including Cheung, Chinn, and Fujii (2007) and Kravis and Lipsey (1987) suggest that the income effect on prices could vary between economies at different stages of developments and is stronger for developed than for developing economies. Since the stage of development is closely related to the level of income, the high income group tends to experience a strong Penn effect. Do we observe a similar phenomenon in Japan?

**Figure 3. Penn effects for the high and low income Japanese sub-samples**



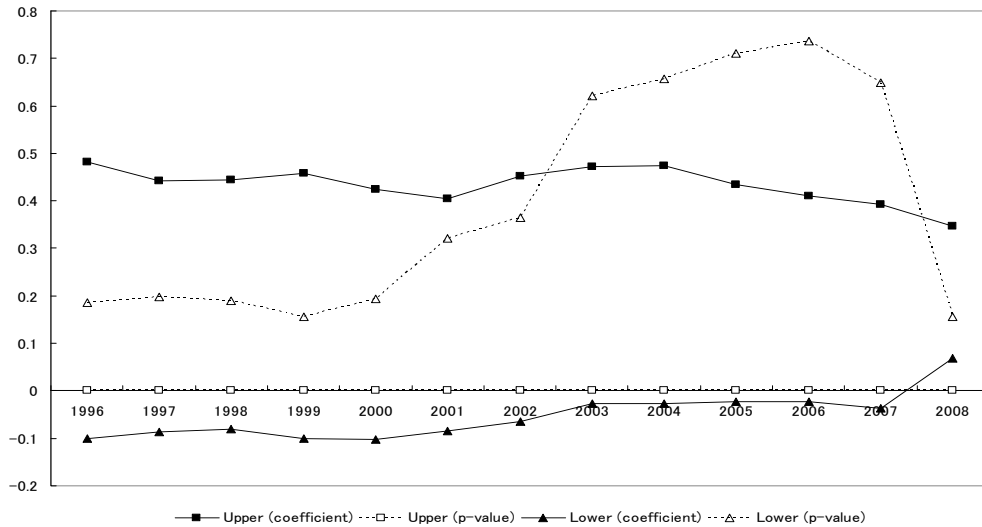
Notes: The figure plots the Penn effect coefficient estimates and their p-values of the high and low income Japanese sub-samples obtained from (5) in the main text.

By ranking the 47 Japanese prefectures according to their *per capita* income, we construct two subsamples – the upper and lower income groups whose income levels are, respectively, above and below the median level. The cross-sectional Penn effect regression (5) was re-run on each of these two subsamples. The year-by-year  $\hat{\lambda}$ s graphed in Figure 3 clearly show that the Penn effect is mainly an upper income group phenomenon. The  $\hat{\lambda}$ s from the upper income group are larger than those from the lower income group and those in Figure 1. More importantly, the upper income group estimates are statistically significant while the lower income group ones are not.

Figures 4 and 5 plot the year-by-year estimates,  $\hat{\lambda}$ s, from the upper and lower income group samples constructed in a similar fashion using the PWT (version 7.0) and the WDI, respectively. While the numerical values are different from those in Figure 3, the quality results pertaining to the upper and lower income groups are the same. The high

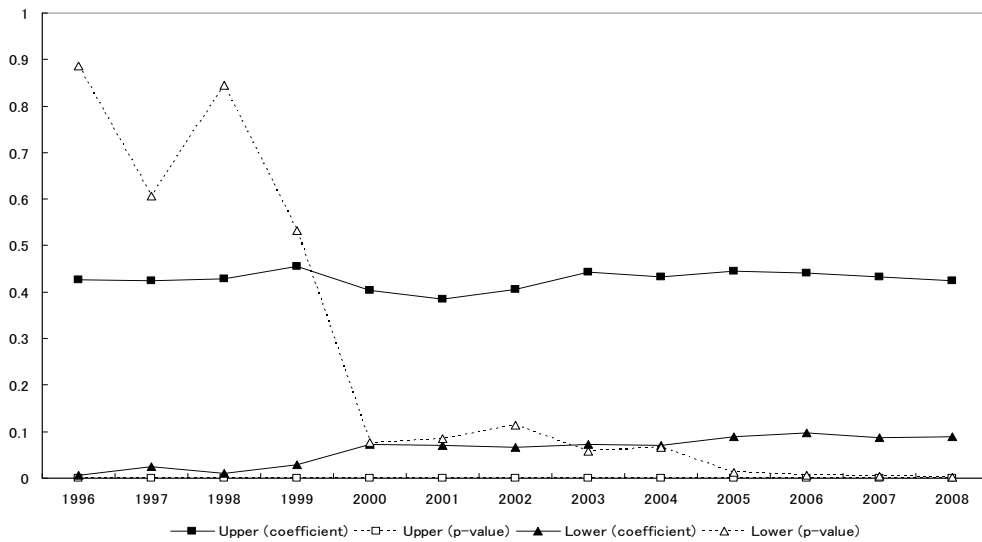
income group gives a significant and large income effect estimate and the lower income group has an insignificant and small estimate.

**Figure 4. Penn effects for high and low income sub-samples of the PWT 7.0 data**



Notes: The figure plots the Penn effect coefficient estimates and their p-values of the high and low income sub-samples of the PWT 7.0 data obtained from (5) in the main text.

**Figure 5. Penn effects for high and low income sub-samples of the WDI data**



Notes: The figure plots the Penn effect coefficient estimates and their p-values of the high and low income sub-samples of the WDI 7.0 data obtained from (5) in the main text.

In sum, similar to cross-country data, the significant income effect on prices displayed by the Japanese data appears to be driven mainly by rich, rather than poor, prefectures.

#### 4. Tradability and Productivity

An eminent explanation for the positive income effect on prices revealed by international data draws on the different price behaviors of nontradables and tradables and the difference in sectoral productivities (Balassa 1964, Samuelson 1964). In this section, we examine the implications of the tradable-nontrable dichotomy (subsection 4.1) and the sectoral productivity differential (subsection 4.2 ) for the Penn effect within Japan.

##### 4.1 Tradables Vs Nontradables

Following (1) and (2) in Section 2.1, the relative price level of two regions, in the presence of a perfectly fixed exchange rate and under the assumption of  $\alpha = \alpha^*$ , is given by

$$p_{j^*,t} - p_{j,t} = \alpha(p_{N,j^*,t} - p_{N,j,t}) + (1 - \alpha)(p_{T,j^*,t} - p_{T,j,t}). \quad (6)$$

Further, if the prices of tradables are the same under the usual arbitrage argument and in the absence of border effects (Engel and Rogers 1996), then the relative price level is merely proportional to the relative price of nontradables. In this case, the price-income relationship essentially reflects the link between prices of nontradables and income levels. Of course, prices of tradables are not necessarily identical across regions. Nevertheless, if prices of tradables, compared with prices of nontradables, are more likely to converge, then the income effect should be more pronounced on prices of nontradables than tradables.

To study implications of the degree of product tradability for the price-income relationship, we estimate the regression specification

$$p_{k,j} = \mu_k + \lambda_k y_j + \varepsilon_{k,j}, \quad (7)$$

where  $k$  denotes a product category. An overarching issue is how to determine which product category is tradable and which is nontradable. The dichotomy between nontradables and tradables is a convenient device in theoretical analyses. In reality, however, most if not all consumer products contain both non-tradable and tradable components. That is, products are neither strictly tradable nor nontradable, but they have different degrees of tradability. Thus, the dichotomy of nontradables and tradables is a too restrictive empirical classification scheme. With the caveat in mind, we use data on disaggregated price indexes to assess the role of tradability.

The list of disaggregated price indexes available at the prefecture level is given in the Appendix, Table A-2. The data on these disaggregated prefecture price indexes are published every five years and only available for 1997, 2002, and 2007 during the sample period under

consideration. The income effect coefficient estimates,  $\hat{\lambda}_k$ s, from product-specific price data are presented in Table 1 and graphed in Figure 6. The estimates from the prefectural consumer price level data are included for references. A few observations are in order.

First, in view of the disaggregated prices listed in Table A-2, the category “goods” is commonly conceived to be more tradable than the category “services.” Indeed, in all years, the income effect coefficient estimate from the “services” category is larger than the one from the “goods” category. Also, the former is highly statistically significant while the latter is statistically insignificant. The results are in line with the notion that the empirical Penn effect is driven by nontradables.

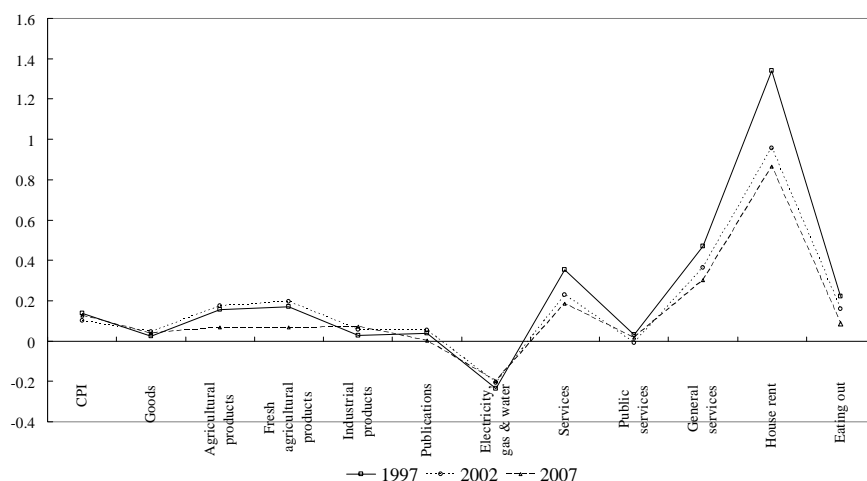
**Table 1. Penn effect by product category**

	1997	2002	2007
CPI	.138** (.029)	.100** (.029)	.128** (.022)
CPI excluding fresh foods	.094** (.020)	.073** (.022)	.105** (.016)
Goods	.025 (.023)	.047 (.030)	.040 (.029)
Agricultural & aquatic products	.154** (.040)	.174** (.039)	.066 (.049)
Fresh agricultural & aquatic products	.170** (.048)	.195** (.044)	.069 (.054)
Industrial products	.028 (.026)	.055 (.033)	.072* (.033)
Publications	.039 (.029)	.054 (.033)	.001 (.025)
Electricity, gas & water charges	-.234** (.058)	-.204** (.061)	-.197** (.058)
Services	.352** (.069)	.229** (.062)	.185** (.049)
Public services	.032 (.036)	-.009 (.019)	.015 (.014)
General services	.470** (.094)	.365** (.086)	.300** (.074)
Private house rent	1.341** (.256)	.957** (.270)	.864** (.244)
Eating out	.221** (.059)	.159** (.035)	.085** (.024)

Notes: The table summarizes the estimation results of (7) in the main text.

Heteroskedastic-consistent standard errors are provided in parentheses underneath the corresponding estimates. \*\*, \* and <sup>†</sup> indicate statistical significance at the 1, 5 and 10 % levels, respectively.

**Figure 6. Income effects on the Japanese disaggregated price indexes**



Notes: The estimates of income effect on price indexes of disaggregated product categories obtained from (7) in the main text are plotted.

Second, it is not precise to consider that the “goods” group consists of products that are equally tradable. Even though data on “goods” have an insignificant  $\hat{\lambda}_k$  estimate, the sub-categories “agricultural & aquatic products” and “fresh agricultural & aquatic products” display a significant price-income relationship for 1997 and 2002.

The results could be attributed to their perishable nature – the products under these two sub-categories have a smaller degree of tradability than, say, that for industrial products. If it is the case, then these perishable products could exhibit the Penn effect like a nontradable product. According to  $\hat{\lambda}_k$  estimates, the “fresh agricultural & aquatic products” yields a stronger income effect than the “agricultural & aquatic products.” The improvements in transportation and storage technologies could enhance the tradability of perishable products, and thus, weaken the Penn effect in the 2007 sample. In passing, it is noted that, the income effect displayed by the data of “CPI excluding fresh foods” is weaker than the one by the “CPI” data.

For the 1997 and 2002 regressions, the income displays no significant effect on the prices of the subcategory “industrial products,” which are in general nonperishable and perceived to be highly tradable. Nevertheless, the income effect turns significant in 2007. While we do not have a definitive explanation for the switch in significance over time, the

results are suggestive of the possibility that the degree of tradability can vary not only across product categories but also over time.

The income effect estimate for “publications” is insignificant. Products in this sub-category including books, magazines and newspapers, tend to have nation-wide listed prices. Such practices may have imposed a restrictive effect on regional price variation and, thus, make the product prices unresponsive to income changes.

The significantly negative coefficient estimates obtained for the “electricity, gas & water charges” sub-category deserves a comment. While this group of products and services are included under the heading of “goods,” they are in most cases utilities and their prices are subject to local administrations and regulations. Water, for example, is usually supplied by municipal governments, whereas electricity and gas are by monopolistic firms in geographically defined markets. Thus, these prices are less likely subject to the usual arbitrage forces. Indeed, our empirical result reveals that the utility charges tend to be relatively lower in wealthier prefectures.

Third, by the same token, products within the “services” category have various degrees of tradability. The “public services” and “general services” sub-categories have starkly different income effects. The “public services” include publicly provided housing, medical and welfare, communication and transportation, and educational services. These services are generally not tradable between prefectures, and their prices tend to be regulated. Our regression result shows that the prices of “public services” are not income sensitive. On the other hand, the price of privately provided “general services” exhibits a highly significant and large income effect. That is, the price of “general services” tends to be higher where real income is higher.

Even under the heading “general services,” the “private house rent” and “eating out” groups have different estimated income effects. While both  $\hat{\lambda}_k$ s are statistically significant, the estimated income effect on private house rent is much stronger than on eating out prices. One speculation is that prevalence of chain-stores in the eating out industry makes the income effect on its price relatively less substantial.

Overall, the prices of products with different degrees of tradability respond differently to income. The Japanese prefectural data yield results that confirm the common wisdom; income tends to have a larger impact on prices of nontradables than on prices of tradables. An implication is that the observed positive association between price and income levels is



largely attributable to nontradables. Of course, the interpretation is subject to the usual caveat that we do not have a precise measure of the degree of product tradability.

#### 4.2 Sectoral Productivity Differential

The difference in the levels of productivity in different sectors is the basis of the Balassa-Samuelson hypothesis (Balassa, 1964; Samuelson, 1964), which is a long-standing explanation of the international price-income relationship.<sup>5</sup> A simple version of the hypothesis is that, assuming the levels of productivity of nontradable sectors are similar across countries and productivity improvement mainly takes place in the tradable sector, a country experiencing a faster productivity growth in the tradable sector will have a higher economic growth rate. Further, assuming prices of tradables are equalized between countries and wages are the same between sectors within a country, the country that experiences a faster productivity growth in the tradable sector will have a higher level of inflation in the nontradable sector. As a result, the country that has a higher level of income will have a higher general price level.

Empirical studies on the productivity differential effect have evolved over time. One key issue is the choice of productivity measure, which has varied from *per capita* gross national product to some specifically constructed measures of sectoral productivity.<sup>6</sup> Further some studies consider (average) labor productivity while others use total factor productivity.<sup>7</sup> The comparison of levels of productivity between countries is further complicated by differing methods to report economic data and varying data quality. These specific data issues are, however, less of a concern when we work with the Japanese prefectural data.

To evaluate relevance of the sectoral productivity differential effect within Japan, we follow De Gregorio, Giovannini, and Wolf (1994) and estimate the cross-sectional regression

$$(p_{N,j} - p_{T,j}) = \mu + \gamma_1 prod_{T,j} + \gamma_2 prod_{N,j} + \delta g_j + \lambda y_j + \varepsilon_j, \quad (8)$$

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<sup>5</sup> Other explanations advocated in the literature include the factor-intensity and factor-endowment approach (Bhagwati 1984; Kravis and Lipsey 1983), and the non-homothetic demand structure approach (Bergstrand 1991).

<sup>6</sup> A sample of these studies includes Balassa (1964), Officer (1976), Hsieh (1982), Asea and Mendoza (1994), De Gregorio, Giovannini, and Wolf (1994), Canzoneri, Cumby and Diba (1999), Chinn (2000), and Kakkar (2003).

<sup>7</sup> For example, Marston (1987) and Canzoneri, Cumby and Diba (1999) use labor productivity, while De Gregorio, Giovannini, and Wolf (1994) and Asea and Mendoza (1994) use total factor productivity.

where  $prod_{T(N),j}$  is the proxy for the level of productivity in the tradable (nontradable) sector and  $g_j$  is the real government expenditure share of GPI. The government expenditure variable is a demand-side factor and is expected to have a positive coefficient. The presence of the productivity differential effect *à la* Balassa-Samuelson hypothesis implies  $\gamma_1 > 0$  and  $\gamma_2 < 0$ .

We adopt the average product of labor approach to measure productivity due to the lack of prefecture-level sectoral data to calculate total factor productivity. Specifically, prefectural data on “value of manufacturing goods shipments, etc.” and “persons at work in manufacturing establishments” are used to construct the proxy  $prod_{T,j}$  for the productivity in the tradable sector. The proxy for the nontradables productivity,  $prod_{N,j}$ , is from data on “annual sales of commercial goods (retail trade)” and “total number of employees (retail trade).”

The results of estimating (8) and its variants are presented in Table 2. Because the price indexes corresponding to the product categories used to construct the measures of nontradables and tradables productivities are not available, we selected proxies for these price indexes based on the results reported in the previous section. Specifically, we used the price of “general services” as the proxy for the price of nontradables  $p_{N,j}$ . For the tradable price, we considered two alternative proxies; namely, the prices of “industrial products” and “goods.” The results of the relative sectoral price ( $p_{N,j} - p_{T,j}$ ) constructed from the two tradable prices are given in Panels A and B, respectively.

The results based on the full specification of (8) – the specification 4 in Table 2 - in general are not encouraging. For the three years (1997, 2002, and 2007) that the disaggregated price data are available, the coefficient estimates are generally insignificant. The nontradables productivity variable garners the largest proportion of significant coefficient estimates – it has a significant coefficient estimate in four of the six cases by conventional criteria. However, when this coefficient estimate is significant, it has a positive sign contrary to the assertion of the Balassa-Samuelson hypothesis. For the tradable productivity variable, none of its six estimates is significant and all of them have a negative sign instead of a positive one predicted by theory.

The coefficient estimates of the government spending variable are mostly insignificant and have a negative sign. In cross-country studies, it is typically hypothesized that a greater government expenditure share exerts a more substantial demand shifting effect.

**Table 2. Effects of productivity differentials**

	1997				2002				2007			
	1	2	3	4	1	2	3	4	1	2	3	4
<i>A. Industrial products</i>												
Tradable productivity		.107*	.028	-.014		.042	-.003	-.041		.013	-.000	-.023
		(.048)	(.066)	(.072)		(.028)	(.037)	(.037)		(.022)	(.027)	(.026)
Nontradable productivity		.402*	.045	-.015		.483**	.234 <sup>†</sup>	.218 <sup>†</sup>		.428**	.274*	.258*
		(.172)	(.184)	(.162)		(.140)	(.131)	(.119)		(.109)	(.114)	(.109)
Income	.442**		.382*	.314	.309**		.220*	.097	.228**		.110 <sup>†</sup>	-.015
	(.086)		(.175)	(.285)	(.058)		(.083)	(.159)	(.049)		(.066)	(.137)
Government spending				-.626				-.609 <sup>†</sup>				-.530 <sup>†</sup>
				(.716)				(.344)				(.311)
Adjusted R <sup>2</sup>	.385	.307	.360	.362	.428	.377	.449	.498	.419	.443	.463	.522
<i>B. Goods</i>												
Tradable productivity		.107*	.025	-.015		.039	-.006	-.041		.019	.003	-.018
		(.047)	(.064)	(.070)		(.028)	(.036)	(.035)		(.021)	(.026)	(.025)
Nontradable productivity		.401*	.029	-.028		.509**	.260*	.244*		.485**	.317**	.301**
		(.164)	(.171)	(.149)		(.140)	(.128)	(.115)		(.103)	(.108)	(.102)
Income	.444**		.398*	.333	.317**		.221**	.105	.260**		.121 <sup>†</sup>	.0004
	(.084)		(.168)	(.271)	(.061)		(.081)	(.158)	(.048)		(.066)	(.130)
Government spending				-.596				-.575				-.508 <sup>†</sup>
				(.680)				(.342)				(.301)
Adjusted R <sup>2</sup>	.407	.319	.382	.383	.445	.407	.478	.521	.489	.523	.547	.595

Notes: The table summarizes the estimation results of (8) in the main text. Heteroskedastic-consistent standard errors are provided in parentheses underneath the corresponding estimates. \*\*, \* and <sup>†</sup> indicate statistical significance at the 1, 5 and 10 % levels, respectively.

toward locally produced nontradables and, thus, a higher general price level. The result in Table 2 lends no support to this hypothesis. Instead, it illustrates that, for regions within a country, fiscal re-distribution towards economically depressed regions could play an important role in determining the sign of the government spending variable.

The results of estimating the variants of (8) offer some clues on the full specification results. For instance, the income variable by itself is always significantly positive. That is, the general prediction of the Balassa-Samuelson hypothesis on the income effect is supported by the Japanese prefectural data.

When the tradables and nontradables productivity variables are the only regressors, the tradables productivity variable yields a correctly signed coefficient estimate. The nontradables productivity variable, on the other hand, still garners an incorrectly signed coefficient estimate. Apparently, the nontradables productivity variable does not behave in the way described by the productivity differential effect underpinning the Balassa-Samuelson hypothesis.

To further investigate the phenomenon, we examined the correlation coefficients of the regressors using all the 1997, 2002, and 2007 observations (Table 3). Apparently, there is some evidence of multi-collinearity. For instance, the income variable has a correlation coefficient of 0.76 with the nontradables productivity variable and -.81 with the government spending variable. Further the government spending variable has a correlation coefficient at least 0.6, in magnitude, with other regressors. The negative correlation coefficients associated with the government spending variable reflects the fiscal transfer policy aiming at low income prefectures. These high correlations could be the culprit of insignificant estimation results.

**Table 3. Correlations between explanatory variables**

	Income	Tradable productivity	Nontradable productivity	Government spending
Tradable productivity	.49			
Nontradable productivity	.76	.22		
Government spending	-.81	-.63	-.60	
Agglomeration	.33	.06	.31	-.33

Notes: The table gives correlation coefficient estimates between explanatory variables considered in the main text. These estimates are computed using data pooled from the 1997, 2002, and 2007 samples.

The income variable has a higher correlation with the nontradables productivity variable stronger than with the tradables productivity variable. The observation seems to be at odds with the assertion that income growth is mainly driven by productivity growth in the tradables sector and the mechanism underlying the productivity differential argument. It is noted some of the standard assumptions underlying the Balassa-Samuelson hypothesis may not hold for the Japanese data. For instance, labor is mobile inter-regionally and tradables may not be produced in all regions. Thus, the results pertaining to these productivity measures should be interpreted with caution.

A caveat is that, even though our data are free from the issues inflicting comparison between countries, productivity measures based on the value of manufacturing goods shipments, the annual sales of commercial goods (retail trade), and labor employment without adjusting for capital may not be ideal proxies for productivity. Unfortunately, we could not find better alternative data on productivity measures.

While acknowledging the limitations of our empirical productivity measures, the results in Table 2 do not lend convincing support to the productivity differential explanation for the observed price-income relationship. We additionally estimated (8) in a panel setting using observations pooled from the three sample years. The results pertaining to the productivity measures are qualitatively similar to those in Table 2. To conserve space, these additional results are not reported but are available upon request.

## **5. Agglomeration Effect**

Interestingly, the inter-prefecture price-income relationship could be analyzed through the prism of regional and urban economics. One channel starts with the presumption that a region enjoys organic growth when it has experienced location-specific economies of scale in the production of, say, tradables and, hence, attracted related economic activities to the region (Glaeser 2008; Henderson 1974; Krugman 1991).<sup>8</sup>

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<sup>8</sup> The extent of the economies of scale depends on the skill profile of the agglomerated heterogeneous labor forces; see Moretti (2004).

The agglomeration of economic activities generates productivity gains, and hence, a rise in the wage in the tradable sector.<sup>9</sup> It also pulls up the wage in the nontradable sector assuming inter-sectoral labor mobility. Higher wages attract workers to the region and increase the population density. The growing population density in turn propels the demand for, and, hence, drives up the prices of housing and other local services. Thus, the price of a nontradable product experiences an increase to the extent that there are rises in its demand and in input costs including rents and labor costs. As a result, even though the prices of tradables are equalized between regions, one would observe a comovement between income and the general price level.<sup>10</sup>

According to the agglomeration effect approach, the increase in population density as a consequence of improved economic opportunity is a driver of notradables prices and, hence, the general price level. Further, there can be an incentive to improve labor productivity in the nontradables sector given the increase in the land price and rent, in addition to labor costs.

To evaluate the relevance of the agglomeration explanation, we include a population density variable in the regression analysis. Specifically, we use data on the number of inhabitants per square kilometer in the densely inhabited districts.<sup>11</sup> The augmented regression equation is

$$(p_{N,j} - p_{T,j}) = \mu + \tau did_j + \gamma_1 prod_{T,j} + \gamma_2 prod_{N,j} + \delta g_j + \lambda y_j + \varepsilon_j, \quad (9)$$

where  $did_j$  is the population density variable expressed as a deviation from the prefectural average and in log. The agglomeration effect implies  $\tau > 0$ . It is noted that the densely inhabited district population data are available only every five-years and for 1995, 2000, and 2005 during our sample period. Thus, 1995, 2000, and 2005 population data are paired up with the corresponding 1997, 2002, and 2007 disaggregated price data to conduct the year-by-year cross-sectional analysis.

Tables 4-1, 4-2, and 4-3 present the results of estimating (9). Across the three individual years and the alternative combinations of prices of tradables and nontradables, the population density variable,  $did_j$ , has a significantly positive coefficient estimate. While the

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<sup>9</sup> For instance, Ciccone and Hall (1996) provides empirical evidence of agglomeration effect on productivity. Glaeser and Maré (2001) presents evidence that cities (i.e. agglomerated urban areas) make workers more productive by speeding up the accumulation of human capital.

<sup>10</sup> It is implicitly assumed that different regions have a similar level of non-labor income.

<sup>11</sup> The densely inhabited districts are in general those that have more than four thousands inhabitants per square kilometer by the population census.

magnitude of the population density effect shrinks somewhat in the presence of other regressors, its significance remains intact. In addition to the statistical significance, the explanatory power of the population density variable is quite high. The adjusted R-squares estimates in Table 2 and Tables 4-1 to 4-3 suggest that, compared with other individual regressors, the population density variable explains the largest marginal fraction of variations in the relative price of nontradables to tradables between the Japanese prefectures. The results lend support to the presence of agglomeration effects.

**Table 4-1. Agglomeration effect – the 1997 sample**

	1	2	3	4
<i>A. Industrial products</i>				
Agglomeration	.314** (.042)	.251** (.031)	.252** (.029)	.257** (.031)
Tradable productivity				.036 (.048)
Nontradable productivity				.123 (.098)
Income		.277** (.049)	.136 <sup>†</sup> (.073)	.063 (.103)
Government spending			-.573* (.271)	-.393 (.300)
Adjusted R <sup>2</sup>	.577	.707	.721	.714
<i>B. Goods</i>				
Agglomeration	.307** (.043)	.243** (.032)	.243** (.030)	.248** (.031)
Tradable productivity				.032 (.046)
Nontradable productivity				.105 (.101)
Income		.285** (.050)	.153* (.069)	.091 (.097)
Government spending			-.535* (.262)	-.372 (.294)
Adjusted R <sup>2</sup>	.574	.719	.731	.723

Notes: The table summarizes the estimation results of (9) in the main text and its variant specifications for the 1997 data. Heteroskedastic-consistent standard errors are provided in parentheses underneath the corresponding estimates. \*\*, \* and <sup>†</sup> indicate statistical significance at the 1, 5 and 10 % levels, respectively.

The income variable maintains its significance in the presence of the population density variable (specification 2). The inclusion of the income variable yields a noticeable marginal increase in the adjusted R-squares estimates. Apparently, the income variable and

population density variable have their own unique information contents in accounting for the price level, and their impacts on prices work through different channels. In other words, after controlling for agglomeration effects, a prefecture with a higher level of income still tends to have a higher relative nontradables-tradables price.

**Table 4-2. Agglomeration effect – the 2002 sample**

	1	2	3	4
<i>A. Industrial products</i>				
Agglomeration	.189** (.033)	.150** (.021)	.146** (.020)	.138** (.018)
Tradable productivity				-.012 (.022)
Nontradable productivity				.165 <sup>†</sup> (.089)
Income		.224** (.040)	.166** (.047)	.092 <sup>†</sup> (.053)
Government spending			-.220 (.153)	-.314* (.154)
Adjusted R <sup>2</sup>	.529	.738	.742	.757
<i>B. Goods</i>				
Agglomeration	.189** (.036)	.149** (.023)	.146** (.022)	.137** (.020)
Tradable productivity				-.012 (.021)
Nontradable productivity				.192* (.092)
Income		.233** (.044)	.186** (.050)	.099 <sup>†</sup> (.055)
Government spending			-.178 (.159)	-.283 <sup>†</sup> (.153)
Adjusted R <sup>2</sup>	.524	.747	.747	.772

Notes: The table summarizes the estimation results of (9) in the main text and its variant specifications for the 2002 data. Heteroskedastic-consistent standard errors are provided in parentheses underneath the corresponding estimates. \*\*, \* and <sup>†</sup> indicate statistical significance at the 1, 5 and 10 % levels, respectively.

The inclusion of the government spending variable and productivity measures does not necessarily improve the regression performance. The government spending is either insignificant or significant with a negative sign. For the two productivity measures, the tradables one is insignificant while the nontradables one is significant in four out of six cases. When significant, the coefficient estimate for the nontradables productivity has a positive



sign. As noted earlier, the positive sign is at odds with the Balassa-Samuelson hypothesis. However, it is possibly consistent with the agglomeration effect explanation. In passing, it is noted from Table 3 that the population density variable and the productivity of nontradable sector are positively correlated – a phenomenon that is consistent with the agglomeration interpretation.

**Table 4-3. Agglomeration effect – the 2007 sample**

	1	2	3	4
<i>A. Industrial products</i>				
Agglomeration	.131** (.032)	.099** (.018)	.093** (.023)	.083** (.023)
Tradable productivity				-.006 (.022)
Nontradable productivity				.175* (.082)
Income		.175** (.022)	.100 (.094)	.019 (.090)
Government spending			-.272 (.248)	-.330 (.223)
Adjusted R <sup>2</sup>	.403	.631	.644	.658
<i>B. Goods</i>				
Agglomeration	.137** (.035)	.099** (.019)	.094** (.023)	.082** (.022)
Tradable productivity				-.001 (.021)
Nontradable productivity				.218* (.081)
Income		.207** (.027)	.133 (.088)	.035 (.081)
Government spending			-.267 (.233)	-.309 (.207)
Adjusted R <sup>2</sup>	.394	.681	.692	.717

Notes: The table summarizes the estimation results of (9) in the main text and its variant specifications for the 2007 data. Heteroskedastic-consistent standard errors are provided in parentheses underneath the corresponding estimates. \*\*, \* and † indicate statistical significance at the 1, 5 and 10 % levels, respectively.

There is a considerable fraction of coefficient estimates in the full specification (9) that are statistically insignificant. The observation is similar to the results in Table 2. Again, the high levels of correlation between some regressors could be the cause of insignificance.

## **6. Concluding Remarks**

In this study, we examine data from the Japanese prefectures and investigate the price-income relationship within a country. Compared with most cross-country analyses, one advantage of using the Japanese data is that prices are measured rather precisely and consistently so that there is little room for product quality differences to influence the empirical results. In addition, the use of the intra-national data effectively eliminates nominal exchange rate volatility effects in comparing price and income levels across locations. Thus, our exercise throws some light on the prevalence and the robustness of the Penn effect, which is commonly documented in cross-country studies.

Our empirical results reveal that the Penn effect is not only an empirical regularity of international data, it is also a staple feature of the Japanese data. Further, the Penn effect within Japan resembles the international one in that the positive price-income relationship is mainly driven by the behavior of the prices of nontradables and not those of tradables. Another commonality is that the income effect on price is stronger among more affluent regions than less affluent ones.

In scrutinizing the Penn effect within Japan, we find mixed evidence for the Balassa-Samuelson hypothesis. It is found that the effect of income is stronger on prices of nontradables than on tradables. However, the roles of the productivities in the tradable and nontradable sectors are in general not the same as those predicted by the hypothesis.

An alternative explanation we considered is the agglomeration effect approach that has not received much attention by studies on the Penn effect. The evidence is rather encouraging. The population density variable that is constructed to represent the degree of agglomeration is found to be a significant factor. In particular, for these Japanese data, most of the empirical specifications that include the agglomeration effect variable could explain over 50% of the variation in the price of nontradables and tradables. The result warrants a future study on the role of the agglomeration approach in explaining the cross-country Penn effect.

## Appendix

### A1. *Data Sources*

The Japanese regional data are obtained from the Regional Statistics Database of the Statistics Bureau, Ministry of Internal Affairs and Communications. The international data are obtained from the PWT 7.0 and the World Development Indicators database (January 2012).

### A2. *The proxy for the productivity of nontradables sector*

For analyses in sections 4.2 and 5, we construct the nontradable productivity proxy variable using data on retail sales and number of workers. Due to the fact that the sales and number of workers are observed with one year lag at the source, our measure of the retail sales per worker series is  $s_{j,t} = \log(X_{j,t-1}/Y_{j,t})$  where  $X_{j,t-1}$  and  $Y_{j,t}$  denote the retail sales and number of workers in prefecture  $j$  for  $t=1997, 2002,$  and  $2007$ . Then, we construct our nontradable productivity proxy variable by  $prod_{NT,j,t} = s_{j,t} - \sum_{j=1}^{47} s_{j,t} / 47$ .

A3. *Additional Tables*

Table A-1. Relative consumer prices and *per capita* gross prefectural incomes 1996-2008

id	Prefecture	$p_{j..}$	$y_{j..}$
1	Hokkaido	0.014	-0.065
2	Aomori	0.001*	-0.182
3	Iwate	-0.007	-0.097
4	Miyagi	-0.003*	-0.028
5	Akita	-0.024	-0.115
6	Yamagata	0.006*	-0.080
7	Fukushima	-0.010	0.030
8	Ibaraki	-0.009	0.041
9	Tochigi	0.004	0.082
10	Gunma	-0.026	-0.002*
11	Saitama	0.025	0.023
12	Chiba	0.006	0.043
13	Tokyo	0.085	0.498
14	Kanagawa	0.070	0.152
15	Niigata	0.006	0.011
16	Toyama	-0.003*	0.138
17	Ishikawa	0.006*	0.092
18	Fukui	-0.004	0.045
19	Yamanashi	0.000*	-0.035
20	Nagano	-0.013	0.047
21	Gifu	-0.013	-0.013
22	Shizuoka	0.030	0.123
23	Aichi	0.026	0.248
24	Mie	-0.008	0.103
25	Shiga	-0.008	0.162
26	Kyoto	0.035	0.019
27	Osaka	0.054	0.127
28	Hyogo	0.022	0.037
29	Nara	-0.002*	-0.092
30	Wakayama	0.003	-0.112
31	Tottori	-0.021	-0.089
32	Shimane	0.007	-0.097
33	Okayama	0.010	0.027
34	Hiroshima	-0.012	0.062
35	Yamaguchi	-0.015	0.033
36	Tokushima	-0.028	-0.031
37	Kagawa	-0.018	-0.020
38	Ehime	-0.039	-0.088
39	Kochi	-0.015	-0.233
40	Fukuoka	0.002*	-0.057
41	Saga	-0.023	-0.111
42	Nagasaki	0.014	-0.209
43	Kumamoto	-0.018	-0.177
44	Ohita	-0.022	-0.010*
45	Miyzaki	-0.047	-0.186
46	Kagoshima	-0.007	-0.194
47	Okinawa	-0.049	-0.285

Notes: The entries are 1996-2008 averages of consumer prices and real *per capita* gross prefectural incomes. For each year, the price ( $p_{j..}$ ) and income ( $y_{j..}$ ) levels are measured in deviations from their all prefecture averages. The entries with “\*” are statistically *not* different from zero at the 5 % significance level.

Table A-2. Product categories of disaggregated regional price indexes

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Goods

- Agricultural & aquatic products
  - Fresh agricultural & aquatic products
- Industrial products
- Electricity, gas & water charges
- Publications

Services

- Public services
  - General services
    - Private house rent
    - Eating out
-

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