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The Penn Effect within a Country – Evidence from Japan

Authors' List

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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 *et al.* (1978), Kravis and Lipsey (1983, 1987), and Summers and Heston (1991). The accumulated evidence attests that compared with poor countries, rich countries tend to have higher price levels. The positive association between income and price levels is considered a fundamental fact of economics (Samuelson, 1994) and conventional wisdom in international economics (Bergin, 2009).

Most studies analyzing the price-income relationship have relied on data derived from the surveys conducted by the International Comparison Program (ICP). Since its establishment in 1968, the ICP has conducted periodic surveys on national prices. The survey results are used to construct internationally comparable price indices and national output data. The ICP has expanded the country sample and product coverage, and improved the survey methodology and data processing procedure over the last few decades to enhance the reliability of the survey.[1] Despite the ICP's continuing efforts, it remains a daunting task to aggregate and compare prices of vastly dissimilar products from countries of different economic characteristics, and over time (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, when countries differ substantially in their output structures and consumption patterns. These differences are not uncommon between countries at different stages of development and with different cultural backgrounds. For a given product, a meaningful comparison of its prices in different countries has to control for its quality attributes; actual or perceived. It is quite difficult to quantify quality differentials for nontradables such as locally provided services.

To alleviate the concerns regarding data incompatibility, the current study investigates the price and income relationship using Japanese regional data. The Japanese data offer a few desirable features. For instance, the price data are collected from national surveys that are designed to cover products of the same quality and quantity attributes across locations. Further, availability of disaggregated price series enables us to examine behavior of sectoral

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[1] The changes in the survey setup led to considerable data revisions that have profound implications for estimates of growth rates, growth determinants, poverty measures, and inequality indicators; see, for example, Johnson *et al.* (2009), Milanovic (2009), Chen and Ravallion (2010a, 2010b), Ciccone and Jarocinski (2010), and Ponomareva and Katayama (2010). On the Penn effect, Cheung *et al.* (2009) and Fujii (2013a) illustrate that, although the positive price-income relation survives data revisions, the magnitude of the estimated income effect has been noticeably changed.

prices. The income data are compiled under identical accounting and tax systems. While consumption bundles may still differ by regions, the degree of consumption homogeneity within Japan is arguably higher than that across countries. In addition, the intra-Japanese comparison is free from the exchange rate volatility effect that sometimes inflicts cross-country comparison.

There are no legal restrictions on either goods or factor flows between regions within Japan. The condition has two implications. First, unlike the international cases, the intra-national price-income relationship is not affected by differences in policies on trade and factor flows. Thus, it is relatively easy to interpret results based on intra-national data. Second, while free trade enhances goods price convergence, free factor movement can generate equalizing pressure on prices and qualities of local services across regions.[2] Of course, the net effect of goods and factor flows depends on the *de facto* mobility rather than *de jure* restrictions because implicit barriers and frictions exist even within a country.[3] Given these differences, it is of interest to compare intra-national estimates to international ones.

In addition to data features, the current study takes an alternative approach and draws upon theories on productivity and economic density (Ciccone and Hall, 1996) to explain the intra-Japan Penn effect. Specifically, the economic density that significantly affects labor productivity is used to explain the price-income relationship observed in the Japanese data. Because good quality regional productivity data in Japan are scarce, the empirical economic density measure offers a good alternative to assess the relevance of the well-known productivity differential effect *à la* Balassa (1964) and Samuelson (1964).

To anticipate the results, we find that, across the Japanese regions, the price and income levels are significantly positively associated with each other. That is, the Penn effect, commonly documented with international data, is also a staple feature of the intra-Japanese data. Our attempts to account for the intra-Japan price-income relationship offer some evidence that the Balassa-Samuelson (B-S) effect retains its relevance in the intra-national context. First, as implied by the usual B-S argument, the positive price-income association is driven essentially by prices of nontradables rather than those of tradables. Further, we find that price differentials across regions are significantly determined and explained by

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[2] In principle, households can migrate to areas where quality services are cheaper *ceteris paribus*. Private service-providers can also choose their locations. The adjustment across regions may take place in terms of either price, quality or both.

[3] For instance, factors such as uneven distribution of industrial locations, climatic differences, and family ties within a region may work as implicit barriers for labor flow. Also, non-negligible transport cost generates market friction for flow of products.

differences in regional economic density characteristics. Under the assumption that economic density is a proxy of productivity, our finding is consistent with the presence of the B-S effect in the Japanese data. Nonetheless, the effect of economic density could have a broader interpretation than the B-S effect because, in addition to the supply-side effect, economic density can affect relative prices of nontradables via the demand-side channel.

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 presents the empirical 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 differentials using data on different product categories. In section 5, we evaluate the role of economic density 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 logarithm, is given by

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

where $p_{N,j,t}$ is the price of nontradables, $p_{T,j,t}$ is the price of tradables, and α defines the weights of the price components. Similarly, the logged aggregate price level of region *j** is

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

To facilitate comparison, the exchange rate of the two regions' currencies is used to convert the two prices $p_{j,t}$ and $p_{j^*,t}$ into the same unit. For our data, the regions are within Japan. Thus, the exchange rate is fixed at unity, and $p_{j,t}$ and $p_{j^*,t}$ can be directly compared.

Two additional assumptions commonly imposed are a) the two prices use the same weight; that is, $\alpha = \alpha^*$, and b) the prices of tradables are the same across different regions so that $p_{T,j,t} = p_{T,j^*,t}$. Under these assumptions, the conventional sectoral productivity differential argument suggests that 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 that inflict cross-country price comparison. In addition to exchange rate volatility, the ability to compare prices is impeded by the fact that aggregate price levels are not necessarily compiled using an identical methodology. Further, prices of tradables are not necessarily the same across countries (Engel and Rogers, 1996). 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 *et al.*, 2010).

2.2 Price Data

We use data from 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, which comprises twenty-three districts of 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 collected by the survey are prices of "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.[4]

It is noted that the consumption tax is completely harmonized across all regions in Japan. In addition, the consumption patterns across these Japanese prefectures are arguably more homogeneous than those across countries. Thus, the prefectural price differentials are less subject to the effects of differential taxes and dissimilar consumption patterns. In sum,

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[4] 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.

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 this study 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 measured by

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

where $RP_{j,t}$ 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 data, 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 prefecture j's real gross prefecture income that includes net factor payments from other prefectures, and population in period t, respectively.[5]

Due to data availability, annual data from 1996 to 2008 are considered. The time averages of $q_{j,t}$ and $y_{j,t}$ are listed in Table A-1 of the Appendix. The relative aggregate price level ranges from about five percentage points below (-0.049, Okinawa) to more than eight percent above (0.085, Tokyo) 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

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

$$q_{j,t} = \mu + \lambda y_{j,t} + \varepsilon_{j,t}. \quad (5)$$

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

The time profile of the slope coefficient estimate $\hat{\lambda}$ and its *p*-value obtained from year-by-year cross-sectional regression are depicted in Figure 1.[6] 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.

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 use the US as the reference country, and include 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 international data are not the same. Further, while the Japanese regional data are CPI-based price data, the PWT and WDI data are GDP-based data. These differences should be considered in comparing these $\hat{\lambda}$-estimates.

In line with the extant literature, the Penn effect is identified in the two international datasets. As the plots indicate, the income effects exhibited by these international data are more substantial than the one by the Japanese data; 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 differences, however, the three datasets unanimously exhibit significant positive income effects on price levels, which is a defining signature of the empirical Penn effect. In sum, despite the differences in data compilation and construction methods, the Penn effect appears a prevalent phenomenon in both the cross-country and intra-Japan data.

The results thus far indicate that price and income levels of Japanese prefectures are positively related to each other – a relationship that is also revealed by cross-country data. The Penn effect in Japan is qualitatively similar though not quantitatively identical to the cross-country Penn effect.

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[6] Since both the dependent and independent variables are deviations from the respective sample averages, the intercept μ is zero by construction. Thus, the constant estimates are insignificantly different from zero and not reported for brevity.

4. Prices of Nontradables and Tradables

A common explanation of the positive income effect on prices 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 for the intra-Japan positive price-income association.

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.

The implication of the degree of tradability is examined using the specification:

$$q_{k,j,t} = \mu_k + \lambda_k y_{j,t} + \varepsilon_{k,j,t} , \quad (7)$$

where $q_{k,j,t}$ is the relative price index of product category *k* in region *j* at time *t* derived based on the procedure defined by (3) using data on the corresponding sub-price index of the RDICP. 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. Products are neither strictly tradable nor nontradable, but have different degrees of tradability. Thus, as an empirical classification scheme, the dichotomy of nontradables and tradables is quite restrictive. With the caveat in mind, we use data on price indexes of different product categories to assess the role of tradability.

The list of prefecture product-category price indexes is given in the Appendix, Table A-2. The data on these prefectural sub-indexes of the RDICP are published every five years and available only for 1997, 2002, and 2007 during the sample period under consideration. The year-by-year income effect coefficient estimates, $\hat{\lambda}_k$ s, from product-category-specific price index data are presented in Table 1 and graphed in Figure 3. The estimates from the prefectural consumer price level data are included for comparison purposes. The last column of Table 1 additionally reports the estimates by pooling the data from the three sample years. A few observations are in order.

First, in view of the disaggregated prices listed in Table A-2, the category “services” is commonly conceived to be less tradable than the category “goods.” Indeed, in all years, the income effect coefficient estimate of the “services” category is larger than that of the “goods” category. Further, the former is statistically significant while the latter is not. The results are in line with the notion that the Penn effect is driven by nontradables.

Second, the “goods” group consists of products that are not 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 characteristic. These two perishable sub-categories are likely to have a lower degree of tradability than, say, industrial products, and exhibit the Penn effect like a nontradable product. According to $\hat{\lambda}_k$ estimates, the group of “fresh agricultural & aquatic products” yields a stronger income effect than the group of “agricultural & aquatic products.” The improvements in transportation and storage technologies enhance the tradability of perishable products, and thus, weaken the Penn effect in the 2007 sample. It is also noted that, the income effect exhibited by the “CPI excluding fresh foods” category 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 became 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 limit the variability of regional prices, and 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 sub-category is included under the heading of "goods," its components are mostly 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.

The culprit of negative coefficient estimates could be the economies of scale effect underlying the provision of public services and utilities. For instance, if there is a large fixed cost of providing electricity and gas services, the average utility charge can decline with the population and the number of households using the services. In our prefectural dataset, the population size is positively correlated with the income level. Thus, compared with less affluent prefectures, more affluent prefectures can have lower utility charges.[7]

Third, by the same token, products within the "services" category have different degrees of tradability. The "public services" and "general services" sub-categories have starkly different income effects. The "public services" include public 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 results show that the prices of "public services" are income insensitive. 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.

The two subgroups of "general services;" namely, the "private house rent" and "eating out" differ substantially in their income coefficient estimates. While both $\hat{\lambda}_k$ s are statistically significant, the estimated income effect on the subgroup of "private house rent" is much stronger than on the subgroup of "eating out" prices. One speculation is that prevalence of chain-stores in the eating out industry weakens the income effect on its price.

The results pertaining to the pooled data are essentially the same as those discussed above. The main exception is that the income effect is significant for the "goods" category, albeit the magnitude is relatively small. The significance can be attributed to the increase in estimation efficiency due to an increase in sample size, and the fact that not all items under the category are tradable.

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

[7] Indeed, on the average, the prefectural price of "electricity, gas & water charges" is lower in prefectures with a larger population size. These results are available upon request.

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.

5. Accounting for the Intra-Japan Penn effect

5.1 Productivity and Economic Density

The difference in the relative sectoral productivity is the basis of the B-S hypothesis, which is a long-standing explanation of the international price-income relationship.[8] 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.[9] Further, some studies consider (average) labor productivity while others use total factor productivity.[10] The comparison of levels of national productivity is further complicated by differences in methods of reporting economic data and in data quality.

Productivity is not directly observable in general. While empirical measures of productivity are routinely used, there are concerns about how well the empirical measures can capture the notion of productivity used in theoretical models. Indeed, because of the paucity of the Japanese prefectural productivity data, we explore alternative proxies for productivity.[11] Specifically, we consider the proxies that are motivated by studies on economic density (Carlino and Voith, 1992; Ciccone and Hall, 1996), and the related agglomeration argument (Henderson, 1974; Krugman, 1991; Glaeser, 2008).

Economic density refers to the intensity of labor, human capital, and physical investment relative to the physical space. Ciccone and Hall (1996) note a few channels through which economic density can affect the level of productivity in a locality: rising-by-distance transport costs from one production stage to the next; externalities associated with physical proximity of production; and a high degree of beneficial

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[8] Other explanations advocated in the literature include the factor-intensity and factor- endowment approach (Kravis and Lipsey, 1983; Bhagwati, 1984), and the non-homothetic demand structure approach (Bergstrand 1991).

[9] For different choices of productivity measures, see, for example, Balassa (1964), Officer (1976), Hsieh (1982), Asea and Mendoza (1994), De Gregorio *et al.* (1994), Canzoneri *et al.* (1999), Chinn (2000), and Kakkar (2003).

[10] For example, Marston (1987) and Canzoneri, Cumby, and Diba (1999) use average labor productivity, while Asea and Mendoza (1994) and De Gregorio *et al.* (1994) use total factor productivity.

[11] Prefectural data constraints are quite severe. We explored the use of proxy measures for labor productivity that are constructed using incomplete prefectural data on sectoral value added and employment. The results obtained from these noisy measures – not reported for brevity but available from the authors – are mostly insignificant.

specialization possible in areas of dense activity. One prediction of their analyses is that a locality with a higher average employment density and a higher inequality of employment density will have a higher level of productivity. There is a caveat however. Increasing economic density generates not only agglomeration effects that raise productivity, but also congestion effects. If congestion effects outweigh agglomeration effects, then a high density area will have a low level of productivity. It is an empirical matter to determine which of the two effects prevails. Using the US state and county data, the authors find that a rise in employment density leads to a significant increase of average labor productivity.[12]

5.2 *Empirical Exploration*

Because prefectural employment density data are not available, we capture the economic density effect using a) the prefectural population density, and b) the population density of the most agglomerated areas within a prefecture. The second variable is based on the population data of densely inhabited districts (DIDs), which are districts that have more than four thousands inhabitants per square kilometer. The two variables correspond to the average employment density and the employment density inequality in Ciccone and Hall (1996). To control for differences between employment and population data, we include data on unemployment rates in our analysis.[13]

The economic density effects are examined using the regression

$$q_{j,t} = \mu + \gamma_1 density_{j,t} + \gamma_2 DID_{j,t} + \gamma_3 UE_{j,t} + \varepsilon_{j,t}\,, \tag{8}$$

where $density_{j,t}$ and $DID_{j,t}$ are, respectively, the number of inhabitants per square kilometer in prefecture *j* and in DIDs in the same prefecture at time *t*. Similarly to the price and income variables, the density variables are in logarithmic terms and expressed as deviations from their respective averages. $UE_{j,t}$ is the unemployment rate deviations from the average at time *t*.

The data on population density and DIDs are available only every five years, and for 1995, 2000, and 2005 during our sample period. Thus, 1995, 2000, and 2005 density data are paired up with the corresponding 1997, 2002, and 2007 disaggregated price data. We estimate (8) using a) year-by-year cross-sectional data, and b) the pooled data while allowing for

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[12] In a similar vein, Carlino and Voith (1992) find that total factor productivity across the U.S. states increases with the level of urbanization, and Glaeser and Maré (2001) report evidence on labor productivity and wages.

[13] An implicit assumption is that unemployment rates, while varying across prefectures, are constant across sectors within each prefecture. Ideally, one should use employment data that are sector-and-prefecture-specific to calculate employment density. However, these data are not available.

year-specific intercepts. To conserve space, we focus on pooled data estimations, and present the year-by-year regression results in the appendix.

According to the economic density reasoning, we expect the two density variables to have positive effects. Assuming that the unemployment rate is constant, a prefecture with a high population density (represented by $density_{j,t}$) has a high average employment density that implies a high level of productivity, a high level of income, and hence, a high general price level. When the average density is held constant, $DID_{j,t}$ reflects the extent of density inequality within a prefecture since it captures essentially the district-specific highest density. A theoretical prediction is that, for a given level of average density, density inequality within a prefecture intensifies the overall effect and boosts the level of productivity. Thus, $DID_{j,t}$ is also expected to exert a positive effect on prices. We expect $UE_{j,t}$ to have a negative effect; a high unemployment rate means a low effective employment density, *ceteris paribus*.

The pooled estimates are summarized in Table 2. As column 1 presents, the average density and DID density variables are jointly significant and positive. The results are in accordance with Ciccone and Hall (1996); that is, the two density variables convey different types of information about price levels. Under the presumption that the economic density variables are proxies for productivity levels, the finding lends support to the link between productivity and price levels. That is, a prefecture with a high level of economic activity and economic activity inequality tends to have a high general price level. The unemployment rate variable has a significantly negative coefficient estimate as expected. The combined explanatory power of these three variables is quite high at the 60% mark.

Do the density effects fully account for the intra-Japan Penn effect? Column 2 evaluates the marginal effect of the income variable. When the income variable is added to (8), the DID variable retains its significance while the average density variable becomes statistically insignificant. The results indicate that the price information content of the income variable dominates that of the average density, and is not identical to the DID density variable. In terms of marginal explanatory power, inclusion of the income variable leads to improvement of the adjusted R-squared estimates albeit relatively small.

Columns 3 to 5 compare the individual effects of the density and income variables.[14] Individually, they all display highly significant price effects. The DID variable coupled with

[14] To capture the employment density effect, the average density and DID density variables are accompanied by the unemployment rate variable.

the unemployment rate offers the highest explanatory power among these three specifications, while the income variable offers the lowest.

Table 3 presents the correlation coefficients between the explanatory variables. The average density variable exhibits sizable correlations of .77 and .58, respectively, with the DID density and income variables. The correlation between the DID density and income variables is lower at .33. The insignificance of the average density effect under column 2 of Table 2 is possibly due to its relatively high degrees of correlation with the other two variables. While there is overlapping in price informational contents, the combined specification considered under column 2 shows that the empirical Penn effect cannot be entirely explained by economic density factors.

The year-by-year results, summarized in Table A-3 in the appendix, convey a very similar message. In general, the average density and DID density variables are jointly significant. The significance of the average density variable is weakened in the presence of the income variable, while that of the DID density variable is not. The relative individual effects and explanatory powers are comparable to those presented in Table 2.

Similar to studies of the B-S effect, we assess the roles of economic density in explaining the relative price of nontradables to tradables using the regression specification:

$$(q_{N,j,t} - q_{T,j,t}) = \mu + \gamma_1 density_{j,t} + \gamma_2 DID_{j,t} + \gamma_3 UE_{j,t} + \varepsilon_{j,t}, \qquad (9)$$

where subscripts *N* and *T* denote nontradables and tradables sectors, respectively.

We note that the two density variables in (9) are not sector-specific and, hence, are not direct measures of the sectoral productivity differentials. However, if cross-prefecture productivity differences in nontradables sectors are negligible as assumed under the B-S hypothesis, then the economic density variables reflect differences in the productivity levels of tradables sectors. Under this assumption, the productivity differential effect argument implies that $\gamma_1 > 0$ and $\gamma_2 > 0$. The assumption and its limitations need to be taken into account when interpreting the empirical results.

The measure of the relative price of nontradables to tradables is based on the relevant sectoral price indices. Based on the results in section 4, we use the price index of “general services” as our proxy for the price of nontradables $q_{N,j,t}$, and the price indices of “industrial products” and “goods” as two alternative proxies for the price of tradables.

In Table 4, panels A and B summarize the pooled estimates for the relative prices based on “industrial products” and “goods”, respectively, as tradables. As displayed in column 1, the density variables jointly attain the expected highly significant positive coefficient estimates. Further, the adjusted R-squared estimate suggests that the density variables along with the unemployment rate variable explain about 60% of the variations in the relative price of nontradables to tradables between the Japanese prefectures.

Some previous international studies report significant demand side effects in modelling the relative nontradable prices. For instance, De Gregorio *et al.* (1994) use *per capita* income as a demand shifter, rather than as a productivity proxy. The results of including the income variable in (9) are presented in column 2. The influences of the presence of the income variable are similar to those revealed by the general price level estimation (column 2 of Table 2); that is, the average density variable becomes insignificant while the DID density variable is still significant. The marginal contribution of the income variable to the overall explanatory power is relatively small in magnitude, albeit the estimate of its coefficient is statistically significant.[15]

Columns 3 to 5 indicate that the economic density and income variables are individually significant with the expected positive effect on the relative prices. The results do not depend on the choice of the proxy for tradable price index. The adjusted R-squared estimates suggest that the economic density variables, as compared to the income, have a higher degree of explanatory power. Overall, the results of the relative price regressions (Table 4) are qualitatively comparable to those of the general price regressions (Table 2).[16]

5.3 Discussion – Economic Density and Prices

In the previous sub-section, we found that the two proxies for economic density have significant positive effects on the Japanese prefecture relative price of nontradables to tradables. Under the presumption that economic density is related to productivity (Ciccone and Hall, 1996), the finding implies that price differentials are related to productivity differentials. If productivity gains tend to concentrate in the tradables sector, then the inference could be extended to the context of sectoral productivity differentials.

While the economic density variables capture productivity effects, the mechanism through which economic density affects the relative price of nontradables to tradables is not

[15] We also considered the real government expenditure share of GPI as an additional control for demand side effects (Froot and Rogoff, 1991; De Gregorio *et al.*, 1994). However, its effect is not found significant in any case. Further, the government expenditure variable exhibits a strong negative correlation with *per capita* income (-.81 by the pooled sample), tending to mask the effect of the income variable. To conserve space, these additional results are not reported but are available upon request.

[16] With some minor yearly variations, the year-by-year estimation results summarized in Tables A-4-1 to A-4-3 in the appendix are qualitatively similar to the results from pooled data reported in the text.

identical to the one underlying the standard B-S explanation. One possible transmission channel is as follows. The agglomeration of economic activities promotes economic opportunities and induces productivity gains in the locality. The productivity gains, in turn, impose pressure on wages in the sector of tradables (Glaeser and Maré, 2001) and, assuming inter-sectoral labor mobility, in the sector of nontradables. Higher wages attract workers to the region, resulting in an increase in the population density. The growing population density in turn propels the demand for locality-specific nontradables including housing and other locally-provided services. Prices of nontradables experience an upward pressure because there is an increase in demand and in input costs including rents.

Under this setup, even though one observes co-movement between income and the general price level, the prices of nontradables are affected by both supply and demand factors.[17] Under the B-S framework, nontradables are produced using labor and capital that have an elastic supply. The economic density approach, however, recognizes the possible role of inelastic supply of land in affecting the prices of nontradables.[18]

The increase in production costs that include land prices and rents will provide incentives to improve labor productivity in the nontradables sector. The economic propagation mechanism underlying the economic density exposition, thus, suggests that the variation in population density can be a proxy for factors that drive nontradables prices, and a locality's population density should be related to its nontradables productivity and income, in addition to its general price level. Both demand and supply factors can be in action. Thus, the empirical economic density effect could be driven by both demand and supply forces, and not necessary the same as the supply-side-driven B-S effect. Our empirical findings, nevertheless, show that the Penn effect represented by the income effect is not entirely explained by economic density.

6. Concluding Remarks

The Japanese prefectural data are employed to investigate the price-income relationship, which is known as the Penn effect. Compared with most cross-country analyses, one advantage of using the Japanese data is that the empirical finding is less likely to be affected by product quality differentials as the Japanese prices are measured rather precisely and consistently. In addition, the use of the intra-national data effectively eliminates nominal

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[17] It is implicitly assumed that different regions have a similar level of non-labor income.

[18] In the B-S model, inter-regional perfect mobility and, hence, elastic supply of capital play an essential role in deriving the result that the regional prices of nontradables are determined solely by supply factors.

exchange rate volatility that could distort the observed link between price and income levels across locations. Thus, our investigation offers a less ambiguous way to infer the prevalence and robustness of the Penn effect, which is commonly documented in cross-country studies.

Our empirical results reveal that the widely documented cross-country positive price-income association is also a staple feature of the Japanese data. The observed intra-Japan Penn effect resembles the international one in that it is driven mainly by the behavior of the prices of nontradables rather than tradables.

In accounting for the intra-Japan Penn effect, we draw on studies of economics of agglomeration and, specifically, implications of economic density on productivity. The notion of economic density offers an alternative way to infer the link between productivity, income, and price levels that is different from the usual B-S interpretation.

We find strong evidence that the relative prices of nontradables to tradables in Japan are driven by regional economic density characteristics. The empirical economic density variables are found to possess large incremental explanatory power. For most specifications considered, the economic density variables explain about 60% or more of the variation in the Japanese prefectural price differential of nontradables and tradables. Although the income effect on (relative) prices is weakened in the presence of economic density variables, the intra-Japan Penn effect cannot be totally explained by the productivity-cum-economic-density nexus. In other words, the income and density variables we adopted contain some non-overlapping information about prices. Informational contents of *per capita* income differentials can be broad and multifaceted. A higher income level can be simultaneously an outcome of a higher productivity level and a source of a greater demand for goods and services. Since our economic density variables also reflect both demand and supply factors, it is possible that they cover different facets of demand and supply forces that drive price variability. Our results warrant a future study on the roles of the B-S hypothesis and the agglomeration and economic density approach in explaining the Penn effect.[19]

[19] As illustrated in Appendix A3, the income effect on prices among rich prefectures is different from the one among poor prefectures. It is another area warrants additional analyses.

Appendix

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).

Appendix A2. Additional Tables

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

id	Prefecture	$q_{j,\cdot}$	$y_{j,\cdot}$
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	Oita	-0.022	-0.010*
45	Miyazaki	-0.047	-0.186
46	Kagoshima	-0.007	-0.194
47	Okinawa	-0.049	-0.285

Notes: The entries are 1996-2008 averages of relative consumer prices and real *per capita* gross prefectural incomes. For each year, prefectural price and income levels are measured in logged 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

<u>Goods</u>		
	Agricultural & aquatic products	
		Fresh agricultural & aquatic products
	Industrial products	
	Electricity, gas & water charges	
	Publications	
<u>Services</u>		
	Public services	
	General services	
		Private house rent
		Eating out

Table A-3. Density effects on the price level by year

A. 1997	1	2	3	4	5
Average density	.011**	.005	.024**		
	(.004)	(.006)	(.004)		
DID density	.076**	.075**		.113**	
	(.016)	(.014)		(.016)	
Unemployment	-.008*	-.005	-.005	-.008*	
rate	(.003)	(.004)	(.004)	(.004)	
Income		.055†			.138**
		(.029)			(.029)
Adjusted R^2	.685	.703	.548	.626	.425

B. 2002	1	2	3	4	5
Average density	.008*	.005	.017**		
	(.004)	(.006)	(.004)		
DID density	.053**	.053**		.080**	
	(.015)	(.014)		(.015)	
Unemployment	-.010*	-.007	-.007	-.010*	
rate	(.003)	(.005)	(.004)	(.004)	
Income		.027			.100**
		(.038)			(.029)
Adjusted R^2	.514	.512	.417	.336	.296

C. 2007	1	2	3	4	5
Average density	.007	.002	.019**		
	(.004)	(.005)	(.004)		
DID density	.060**	.061**		.085**	
	(.017)	(.016)		(.013)	
Unemployment	-.010**	-.006*	-.007**	-.010**	
rate	(.002)	(.003)	(.002)	(.002)	
Income		.055*			.128**
		(.027)			(.022)
Adjusted R^2	.603	.624	.509	. 585	.427

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

Table A-4-1. Density effects on relative sectoral prices – the 1997 sample

	1	2	3	4	5
A. Industrial products					
Average density	.046**	.022†	.081**		
	(.009)	(.013)	(.010)		
DID density	.209**	.205**		.356**	
	(.039)	(.039)		(.047)	
Unemployment rate	-.015†	-.003	-.006	-.015	
	(.008)	(.010)	(.010)	(.010)	
Income		.200*			.442**
		(.078)			(.086)
Adjusted R^2	.684	.706	.595	.599	.385
B. Goods					
Average density	.048**	.025†	.081**		
	(.009)	(.013)	(.011)		
DID density	.201**	.198**		.353**	
	(.038)	(.038)		(.049)	
Unemployment rate	-.017†	-.004	-.007	-.017	
	(.008)	(.011)	(.011)	(.011)	
Income		.194*			.444**
		(.075)			(.084)
Adjusted R^2	.700	.721	.614	.604	.407

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 † indicate statistical significance at the 1 , 5 and 10 % levels, respectively.

Table A-4-2. Density effects on relative sectoral prices – the 2002 sample

	1	2	3	4	5
A. Industrial products					
Average density	.025**	.012	.054**		
	(.008)	(.010)	(.008)		
DID density	.166**	.165**		.246**	
	(.028)	(.026)		(.028)	
Unemployment rate	-.026**	-.017*	-.017**	-.027**	
	(.004)	(.007)	(.006)	(.005)	
Income		.120*			.309**
		(.048)			(.058)
Adjusted R^2	.743	.764	.593	.681	.428
B. Goods					
Average density	.026**	.014	.055**		
	(.008)	(.011)	(.009)		
DID density	.168**	.167**		.251**	
	(.028)	(.025)		(.030)	
Unemployment rate	-.028**	-.019*	-.019**	-.029**	
	(.004)	(.007)	(.006)	(.005)	
Income		.116*			.317**
		(.049)			(.061)
Adjusted R^2	.765	.784	.612	.699	.445

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 * indicate statistical significance at the 1 and 5 % levels, respectively.

Table A-4-3. Density effects on relative sectoral prices – the 2007 sample

	1	2	3	4	5
A. Industrial products					
Average density	.020*	.008	.038**		
	(.009)	(.010)	(.007)		
DID density	.088*	.089**		.155**	
	(.037)	(.032)		(.028)	
Unemployment rate	-.012**	-.004	-.009**	-.014**	
	(.003)	(.004)	(.002)	(.003)	
Income		.129*			.228**
		(.048)			(.049)
Adjusted R^2	.582	.624	.524	.532	.419
B. Goods					
Average density	.021*	.009	.041**		
	(.008)	(.010)	(.007)		
DID density	.100**	.100**		.169**	
	(.035)	(.031)		(.029)	
Unemployment rate	-.017**	-.009*	-.013**	-.019**	
	(.003)	(.004)	(.002)	(.003)	
Income		.125*			.260**
		(.046)			(.048)
Adjusted R^2	.661	.696	.592	.610	.489

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 and 5 % levels, respectively.

Appendix A3. Penn Effects Among Rich and Poor Prefectures

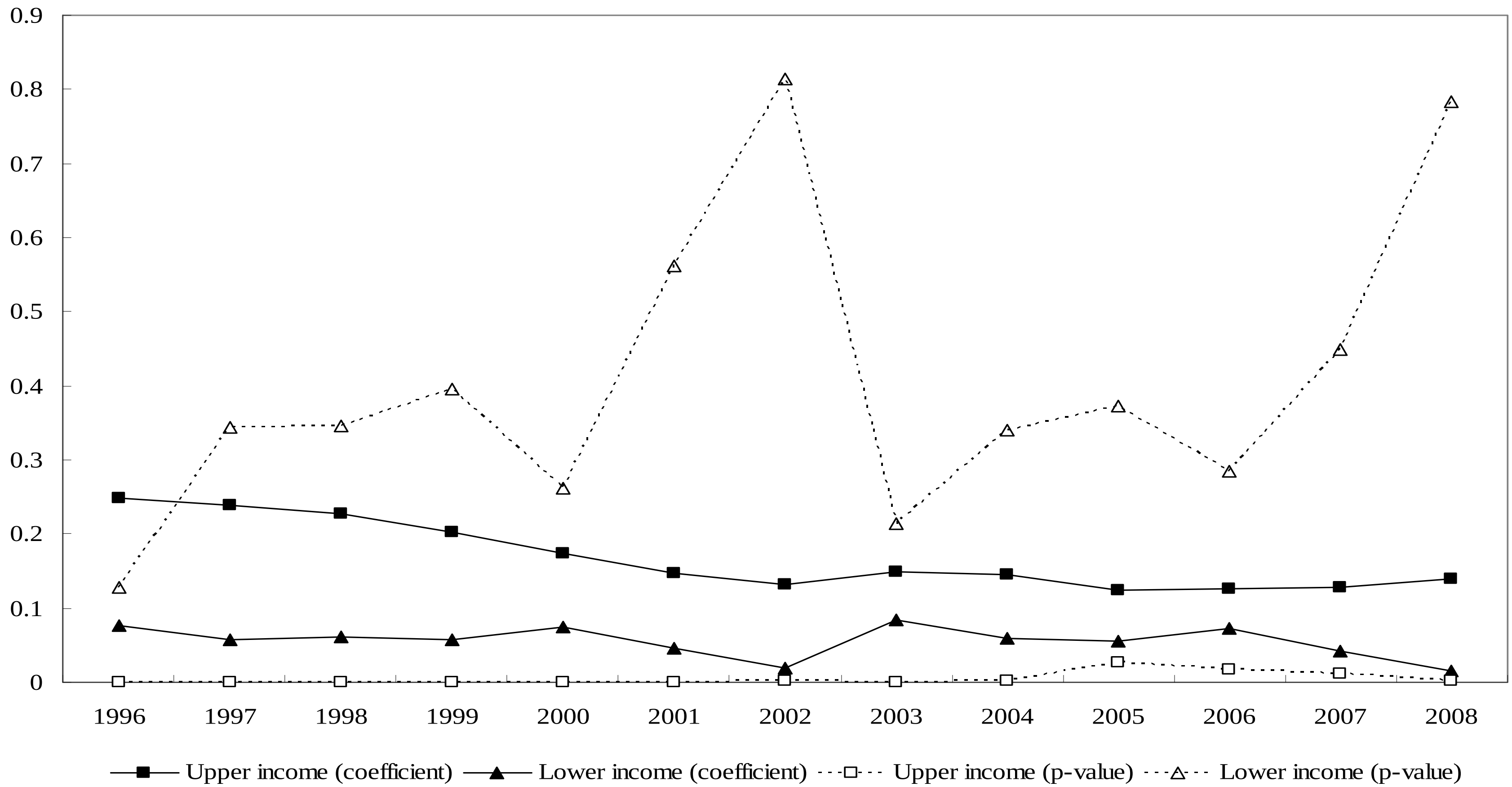
Some studies (Kravis and Lipsey, 1987; Cheung, Chinn, and Fujii, 2007; Fujii, 2013b) suggest that the income effect on prices could vary between economies at different stages of development and is stronger for developed economies than for developing ones. Since the stage of development is closely related to the level of income, the Penn effect tends to be more substantial among higher income countries than lower income countries. Does a similar regularity hold in the intra-Japan context?

To investigate the issue, we rank the forty-seven Japanese prefectures according to their *per capita* income and construct two subsamples – the upper and lower income groups whose income levels are, respectively, above and below the median level. The Penn effect regression (5) was re-run on each of these two subsamples. The year-by-year $\hat{\lambda}$s graphed in Figure A-1 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 A-2 and A-3 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 A-1, the qualitative results pertaining to the upper and lower income groups are the same. The upper income group yields significant and large income effect estimates while the lower income group obtains insignificant and small estimates.

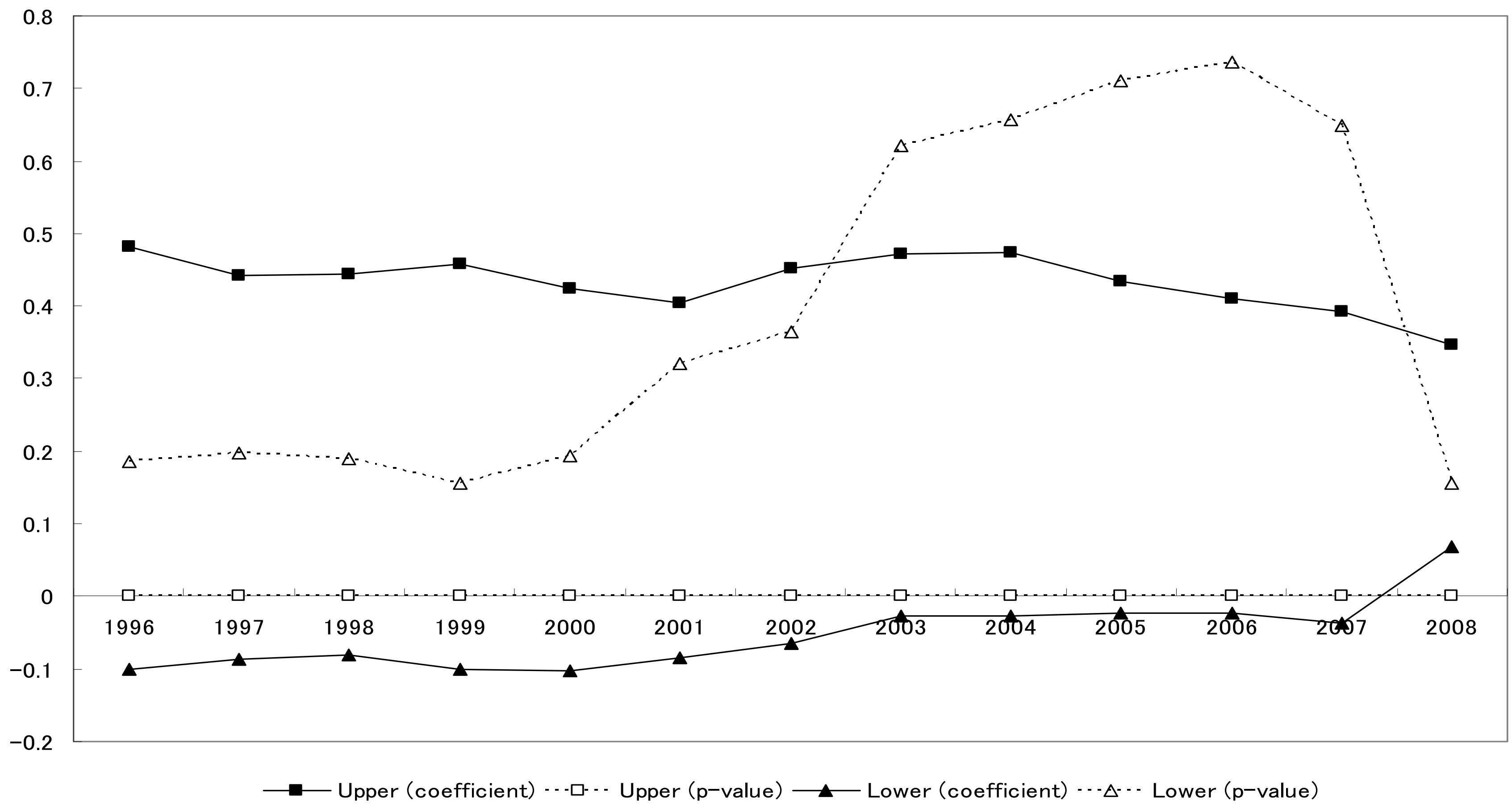
In sum, comparable to the results from the cross-country data, the significant income effect on prices displayed by the Japanese data appears to be driven mainly by rich, rather than poor, prefectures.

Figure A-1. Penn effects for the high and low income Japanese Prefectures



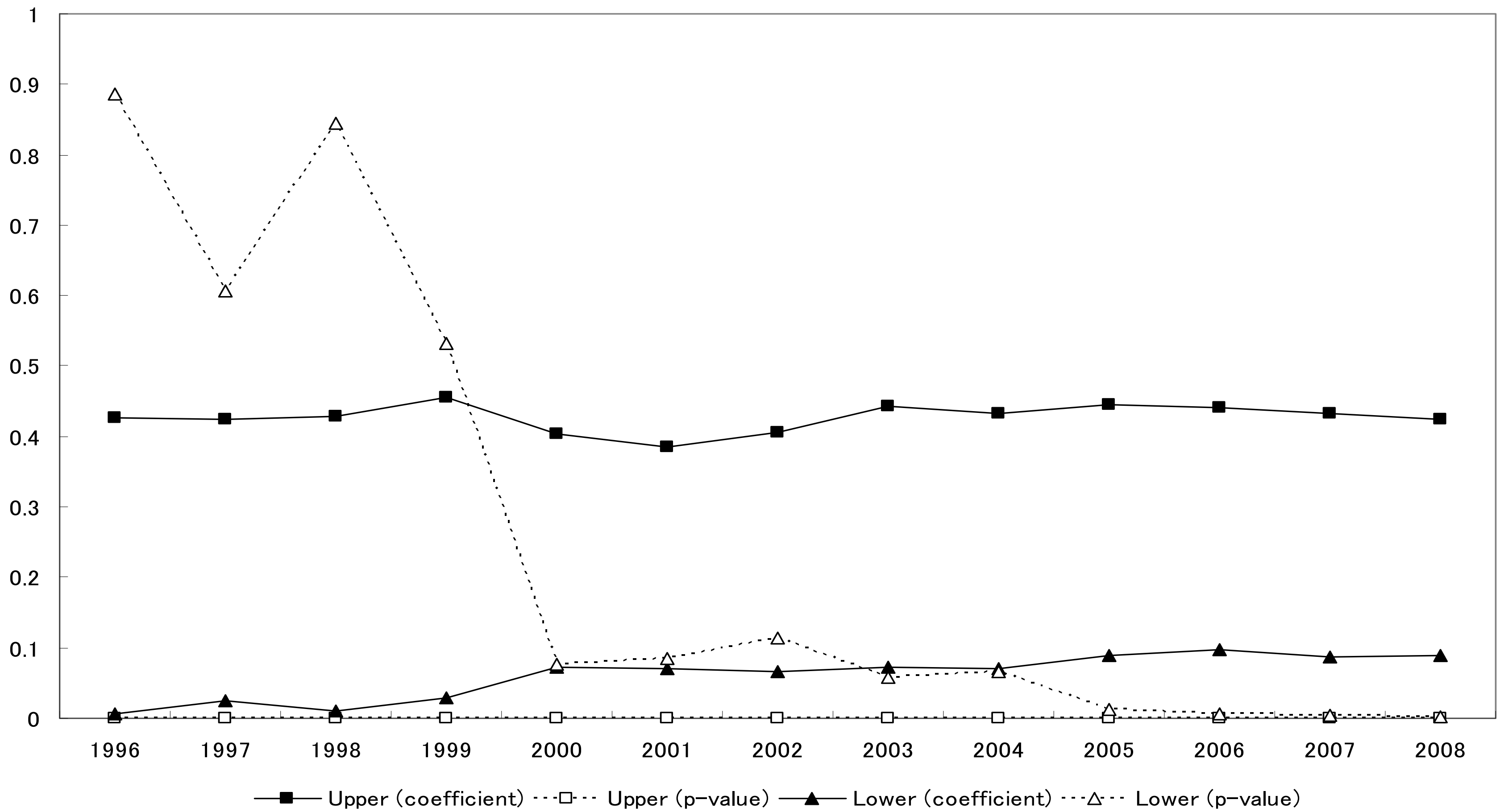
Notes: The figure plots the Penn effect coefficient estimates and their p-values of the high and low income Japanese prefectures sub-samples obtained from (5) in the main text.

Figure A-2. 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 A-3. 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.

Reference

Asea, P. and Mendoza, E. (1994) The Balassa-Samuelson model: A general equilibrium appraisal, *Review of International Economics*, 2, 244-267.

Balassa, B. (1964) The purchasing power doctrine: A reappraisal, *Journal of Political Economy*, 72, 584-96.

Bergin, P.R. (2009) Balassa-Samuelson effect, in K.A. Reinert and R.S. Rajan (eds.) *The Princeton Encyclopedia of the World Economy Volume 1*, Princeton University Press, Princeton, NJ.

Bergstrand, J.H. (1991) Structural determinants of real exchange rates and national price levels: Some empirical evidence, *American Economic Review*, 81, 325-34.

Bhagwati, J.N. (1984) Why are services cheaper in the poor countries? *Economic Journal* 94, 279-86.

Canzoneri, M.B., Cumby, R.E., and Diba, B. (1999) Relative labor productivity and the real exchange rate in the long run: Evidence for a panel of OECD countries, *Journal of International Economics*, 47, 245-66.

Carlino, G.A. and Voith, R. (1992) Accounting for differences in aggregate state productivity, *Regional Science and Urban Economics*, 22, 597-617.

Chen, S. and Ravallion, M. (2010a) China is poorer than we thought, but no less successful in the fight against poverty, in S. Anand, P. Segal, and J.E. Stiglitz (eds.) *Debates on the Measurement of Global Poverty*, Oxford University Press, New York, NY.

Chen, S. and Ravallion, M. (2010b) The developing world is poorer than we thought, but no less successful in the fight against poverty, *Quarterly Journal of Economics*, 125, 1577-625.

Cheung, Y.-W., Chinn, M., and Fujii, E. (2007) The overvaluation of renminbi undervaluation, *Journal of International Money and Finance*, 26, 762-785.

Cheung, Y.-W., Chinn, M., and Fujii, E. (2009) Pitfalls in measuring exchange rate misalignment: The yuan and other currencies, *Open Economies Review*, 20, 183-206.

Chinn, M. D. (2000) The usual suspects? Productivity and demand shocks and Asia-Pacific real exchange rates, *Review of International Economics*, 8, 20-43.

Ciccone, A. and Hall, R.E. (1996) Productivity and the density of economic activity, *American Economic Review*, 86, 54-70.

Ciccone, A. and Jarocinksi, M. (2010) Determinants of economic growth: Will data tell? *American Economic Journal: Macroeconomics*, 2, 223–47.

Deaton, A. and Heston, A. (2010) Understanding PPPs and PPP-based national accounts, *American Economic Journal: Macroeconomics*, 2, 1–35.

De Gregorio, J., Giovannini, A., and Wolf, H.C. (1994) International evidence on tradable and nontradable inflation, *European Economic Review*, 38, 1225-44.

Engel, C. and Rogers, J.H. (1996) How wide is the border? *American Economic Review*, 86, 1112-25.

Froot, K.A. and Rogoff, K. (1991) The EMS, the EMU, and the transition to a common currency, in S. Fisher and O. Blanchard (eds.) *National Bureau of Economic Research Macroeconomics Annual*, MIT Press, Cambridge, MA.

Fujii, E. (2013a) The Penn effect: Decoupling and re-coupling in the price-income relationship? in Y.-W. Cheung and F. Westermann (eds.) *Global Interdependence, Decoupling, and Re-coupling*, MIT Press, Cambridge, MA.

Fujii, E. (2013b) Reconsidering the Price-Income Relationship across Countries. *CESifo Working Paper* 4129.

Glaeser, E.L. (2008) *Cities, Agglomeration and Spatial Equilibrium*, Oxford University Press, New York, NY.

Glaeser, E.L. and Maré, D.C. (2001) Cities and skills, *Journal of Labor Economics*, 19, 316-42.

Henderson, J.V. (1974) The sizes and types of cities, *American Economic Review*, 64, 640-56.

Hsieh, D.A. (1982) The determination of the real exchange rate: The productivity approach, *Journal of International Economics*, 12, 335-62.

Imbs, J.M., Mumatz, H., Ravn, M.O., and Rey, H. (2010) One TV, one price? *Scandinavian Journal of Economics*, 112, 753-81.

Johnson, S., Larson, W., Papageorgiou, C. and Subramanian, A. (2009) Is newer better? The Penn World Table revisions and the cross-country growth literature, *NBER Working Paper* 15455.

Kakkar, V. (2003) The relative price of nontraded goods and sectoral total factor productivity: An empirical investigation, *Review of Economics and Statistics*, 85, 444-52.

Kravis, I.B., Heston, A., and Summers, R. (1978) *International Comparisons of Real Product and Purchasing Power*, Johns Hopkins University Press, Baltimore, MD.

Kravis, I.B. and Lipsey, R.E. (1983) Toward an explanation of national price levels, *Princeton Studies in International Finance* No. 52, Department of Economics, Princeton University, Princeton.

Kravis, I.B. and Lipsey, R.E. (1987) The assessment of national price levels, in S.W. Arndt and J. D. Richardson (eds.) *Real Financial Linkages among Open Economies*, MIT Press, Cambridge, MA.

Krugman, P.R. (1991) Increasing returns and economic geography, *Journal of Political Economy*, 99, 483-99.

Marston, R.C. (1987) Real exchange rates and productivity growth in the United States and Japan, in S.W. Arndt and J. D. Richardson (eds.) *Real Financial Linkages among Open Economies*, MIT Press, Cambridge, MA.

Milanovic, B. (2009) Global inequality recalculated: The effect of new 2005 PPP estimates on global inequality, *World Bank Policy Research Working Paper* 5061.

Officer, L.H. (1976) The productivity bias in purchasing power parity: An econometric investigation, *International Monetary Fund Staff Papers*, 23, 545-79.

Ponomareva, N. and Katayama, H. (2010) Does the version of the Penn World Tables matter? An analysis of the relationship between growth and volatility, *Canadian Journal of Economics*, 43, 152-79.

Samuelson, P.A. (1964) Theoretical notes on trade problems, *Review of Economics and Statistics*, 46, 145-54.

Samuelson, P.A. (1994) Facets of Balassa-Samuelson thirty years later, *Review of International Economics*, 2, 201-26.

Summers, R. and Heston, A. (1991) The Penn World Table (Mark V): An extended set of international comparisons, 1950-1988, *Quarterly Journal of Economics*, 104, 51-66.

Table 1. Penn effect by product category

	1997	2002	2007	Pooled
CPI	0.138**	0.100**	0.128**	0.122**
	(0.029)	(0.029)	(0.022)	(0.015)
CPI excluding fresh foods	0.094**	0.073**	0.105**	0.092**
	(0.020)	(0.022)	(0.016)	(0.010)
Goods	0.025	0.047	0.040	0.038*
	(0.023)	(0.030)	(0.029)	(0.015)
Agricultural & aquatic products	0.154**	0.174**	0.066	0.127**
	(0.040)	(0.039)	(0.049)	(0.025)
Fresh agricultural & aquatic products	0.170**	0.195**	0.069	0.140**
	(0.048)	(0.044)	(0.054)	(0.028)
Industrial products	0.028	0.055	0.072*	0.053**
	(0.026)	(0.033)	(0.033)	(0.017)
Publications	0.039	0.054	0.001	0.029
	(0.029)	(0.033)	(0.025)	(0.016)
Electricity, gas & water charges	-0.234**	-0.204**	-0.197**	-0.211**
	(0.058)	(0.061)	(0.058)	(0.032)
Services	0.352**	0.229**	0.185**	0.252**
	(0.069)	(0.062)	(0.049)	(0.034)
Public services	0.032	-0.009	0.015	0.013
	(0.036)	(0.019)	(0.014)	(0.013)
General services	0.470**	0.365**	0.300**	0.374**
	(0.094)	(0.086)	(0.074)	(0.046)
Private house rent	1.341**	0.957**	0.864**	1.044**
	(0.256)	(0.270)	(0.244)	(0.140)
Eating out	0.221**	0.159**	0.085**	0.151**
	(0.059)	(0.035)	(0.024)	(0.024)

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 * indicate statistical significance at the 1 and 5 % levels, respectively. Year-specific constants are allowed for the pooled data estimation.

Table 2. Density effects on the price level – the pooled estimates

	1	2	3	4	5
Average density	0.009**	0.004	0.020**		
	(0.002)	(0.003)	(0.002)		
DID density	0.061**	0.061**		0.092**	
	(0.009)	(0.008)		(0.008)	
Unemployment rate	-0.009**	-0.005**	-0.006**	-0.009**	
	(0.001)	(0.002)	(0.001)	(0.001)	
Income		0.051**			0.122**
		(0.018)			(0.015)
Adjusted R^2	0.600	0.623	0.492	0.555	0.386

Notes: The table summarizes the estimation results of (8) in the main text and its variant specifications using sample of the 1997, 2002, and 2007 data. Year-specific constants are included in all specifications. The number of observations is 141. Heteroskedastic-consistent standard errors are provided in parentheses underneath the corresponding estimates. ** and * indicate statistical significance at the 1 and 5 % levels, respectively.

Table 3. Correlations between explanatory variables

	Income	Average density	DID density
Average density	0.58		
DID density	0.33	0.77	
Unemployment rate	-0.36	0.28	0.42

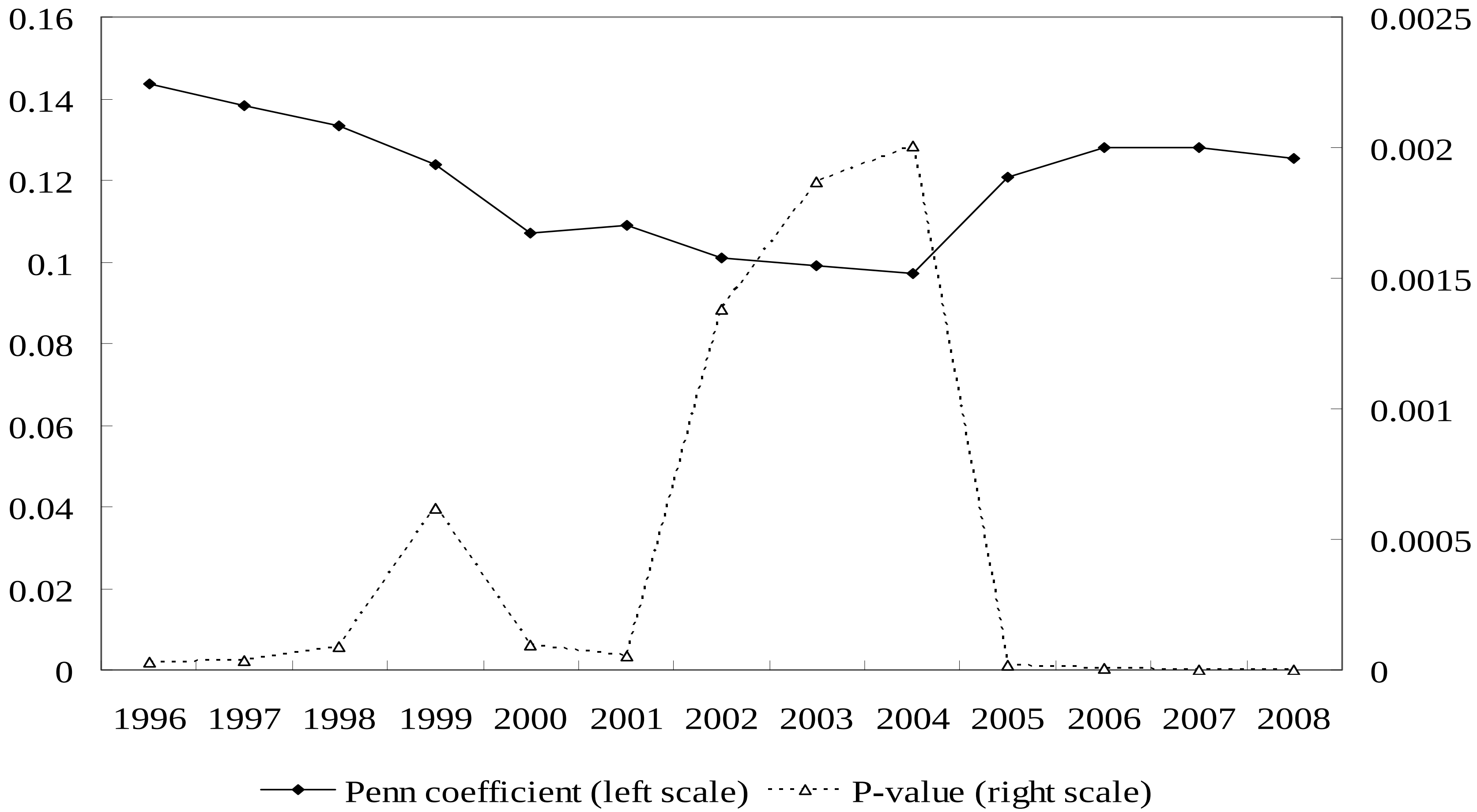
Notes: The table gives correlation coefficient estimates between explanatory variables considered in the main text. These estimates are computed using data pooled from the 1997, 2002, and 2007 samples.

Table 4. Density effects on relative sectoral prices – the pooled estimates

	1	2	3	4	5
A. Industrial products					
Average density	0.031**	0.011	0.056**		
	(0.006)	(0.007)	(0.005)		
DID density	0.140**	0.140**		0.240**	
	(0.023)	(0.022)		(0.022)	
Unemployment rate	-0.014**	-0.002	-0.008**	-0.016**	
	(0.003)	(0.004)	(0.003)	(0.003)	
Income		0.186**			0.321**
		(0.036)			(0.039)
Adjusted R^2	0.598	0.642	0.520	0.528	0.372
B. Goods					
Average density	0.033**	0.013	0.058**		
	(0.006)	(0.006)	(0.005)		
DID density	0.143**	0.143**		0.248**	
	(0.021)	(0.020)		(0.022)	
Unemployment rate	-0.017**	-0.006	-0.011**	-0.019**	
	(0.003)	(0.004)	(0.003)	(0.003)	
Income		0.179**			0.336**
		(0.034)			(0.037)
Adjusted R^2	0.633	0.674	0.552	0.557	0.409

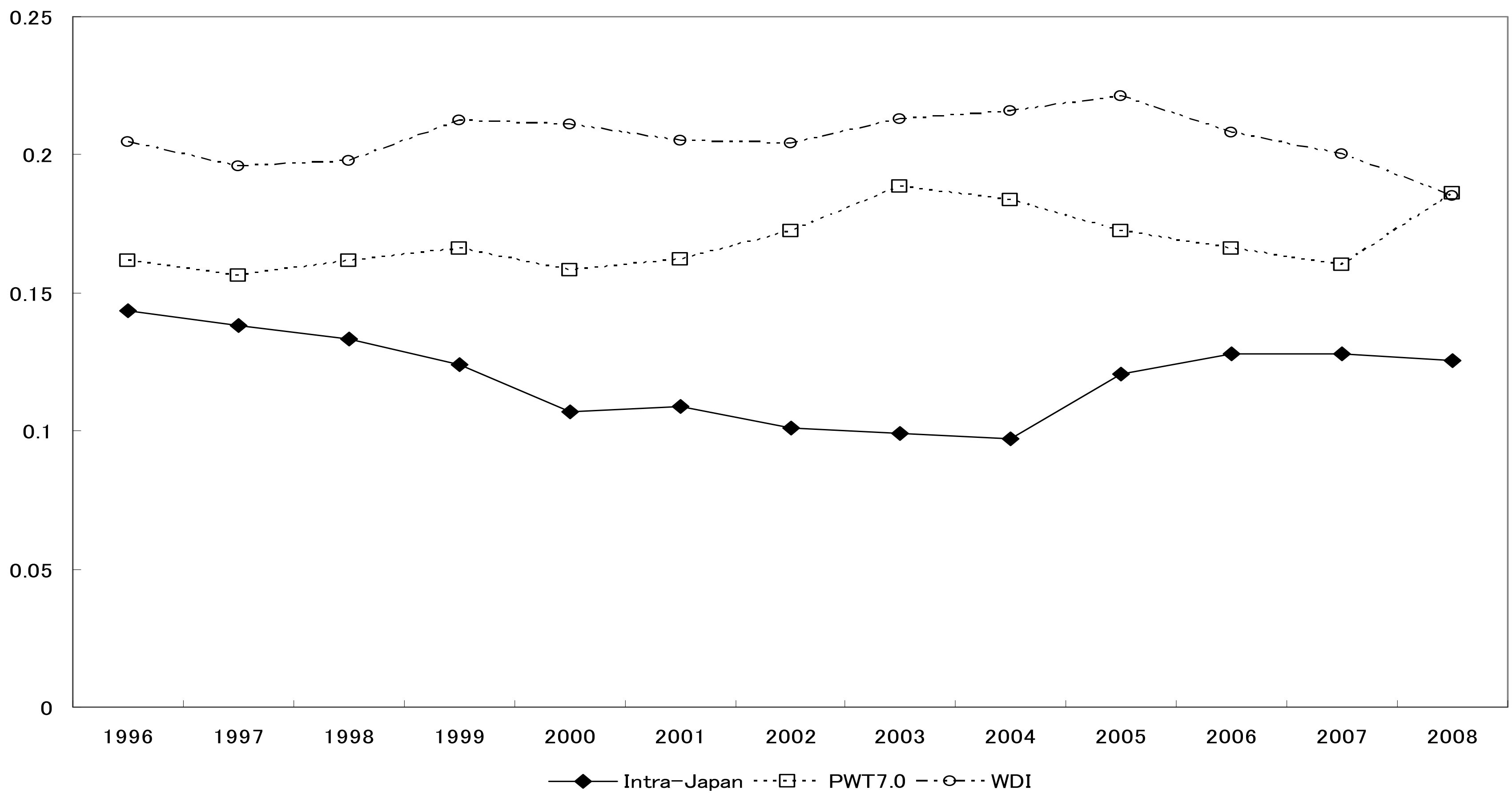
Notes: The table summarizes the estimation results of (9) in the main text and its variant specifications using sample of the 1997, 2002, and 2007 data. Year-specific constants are included in all specifications. The number of observations is 141. Heteroskedastic-consistent standard errors are provided in parentheses underneath the corresponding estimates. ** and * indicate statistical significance at the 1 and 5 % levels, respectively.

Figure 1. Time profile of the Penn effect within Japan



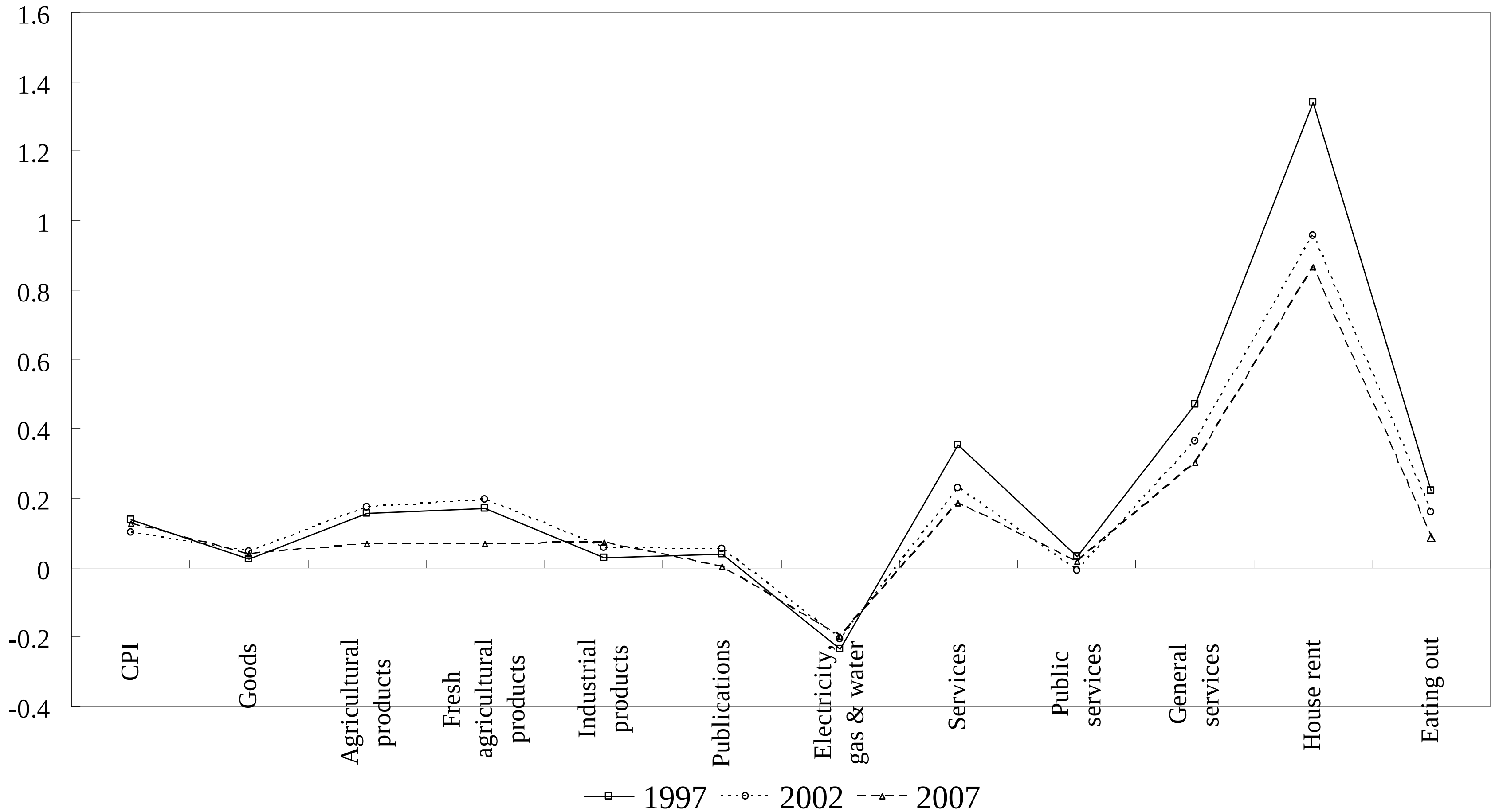
Notes: The figure plots the Penn effect coefficient estimates and their p-values of the Japanese data obtained from (5) in the main text.

Figure 2. The international and intra-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.

Figure 3. Income effects on the Japanese disaggregated price indexes



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