INTERNATIONAL REAL ESTATE REVIEW

2020 Vol. 23 No. 1: pp. 1 – 36

Why Are Housing and Services More Expensive in Rich Countries than in Poor Ones? A Model of Neighborhood Housing Effect and its Evidence

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This paper examines why housing and services are more expensive in rich countries than in poor ones. We propose the Rich Neighborhood Housing Effect (RNHE), which explicitly allows for local labor force heterogeneity with a coherent supply-demand framework that incorporates demand-side factors such as the Linder effect. We also develop a contemporary RNHE model that predicts different behavior of the national price level between high-income and low-income countries. These predictions are confirmed by the panel data from 1990 to 2010 and simultaneous equation estimations. These results are compelling evidence in favor of the RNHE model over the Balassa–Samuelson model.

Keywords

Balassa–Samuelson Model, Rich Neighborhood Housing Effect, National Price Levels, Housing and Services, Linder Effect

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1. Introduction

It is a stylized fact in international economics that the price levels of countries, when converted into a single currency at market exchange rates, are positively related to their real per capita income. In short, rich countries tend to have higher prices. This is so mainly because housing and services, which are nontradable, tend to be more expensive in rich countries.

Why are housing and services more expensive in rich countries than in poor ones? This question has been traditionally explained by the celebrated Balassa–Samuelson (BS) model (Balassa, 1964; Samuelson, 1964) and the slightly less prominent Linder hypothesis (Linder, 1961). On the one hand, the BS model is a supply-side theory that is based on two essential assumptions: 1) within each country, there is a uniform local labor force that is mobile between the tradable and the housing and services sectors, and 2) labor productivity in the tradable sector is higher in rich countries, for some unspecified reasons. The reasoning runs as follows. Given intersectoral labor mobility, wage rates should be equalized between the two sectors. Thus, the higher labor productivity in tradables implies higher tradable sector wages and also higher nontradable-sector wages. Finally, assuming that productivity differences in housing and services are negligible across countries, the higher wages translate into higher prices of housing and services in rich countries.[1] On the other hand, the Linder hypothesis is a demand-side consideration that posits that the demand for housing and services increases relative to that for tradables as a country moves up the income ladder; that is, the income elasticity of demand for non-tradables is greater than 1.

The BS model and Linder hypothesis have been subjected to some obvious criticisms. The most important mechanism envisioned by the BS model crucially hinges on what might be conveniently called the "BS linkage", which is the assumption of a uniform labor force within each country, together with its implications of intersectoral labor arbitrage and intersectoral wage equalization within each country. It is these features that provide the essential causal links between tradable-sector productivity and the prices of housing and services. However, it can be argued that these key features of the BS model are seriously unrealistic for most modern economies.[2] To be sure, the assumption

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[1] A more sophisticated rendering of the above reasoning would allow for significant international productivity differences in housing and services, and only require these to be smaller than productivity differences in tradables.

[2] To the common observer, while it is safe to assume that a Silicon Valley IT engineer with a college degree can always choose to work as a hamburger flipper if s/he wants to do so, it would be absurd to assume that a high school drop-out who is working as a hamburger flipper can equally easily switch to an IT job. This is exactly why IT engineers earn significantly higher wages than hamburger flippers, which, in turn, explains why people invest in their college education and we do not see many potential IT engineers working at McDonalds.

of within-country labor force homogeneity stands in sharp contrast to the practice of the international trade literature, which routinely divides the labor force of a country into skilled and unskilled workers based on skill level/educational attainment, and identifies this labor force heterogeneity as well as differences in the skilled-unskilled wage gap as one of the key drivers of modern international trade. The Linder hypothesis is based on the differences among the consumption structures of countries, that is, the presence of a non-homothetic preference. In reality, the similarities among such structures make it difficult for the Linder hypothesis in explaining price level differences that are not based on the demand-side.

This paper proposes a contrasting theory of national price levels, which we will label the Rich Neighborhood Housing Effect (henceforth RNHE). The RNHE is a more general theory because: 1) it does not rely on the restrictive assumption of labor force homogeneity as the BS model does, but explicitly allows for a local labor force differentiated by skill level, and 2) it is formulated as a coherent supply-demand framework that incorporates demand-side factors such as the Linder effect, and also incorporates the BS model as an unlikely limiting case.

This paper also aims to determine how the RNHE model can be empirically differentiated from the BS model. Since Balassa (1964), many empirical studies, such as Heston, Nuxoll and Summers (1994), Cihak and Holub (2001), and Bergin, Glick, and Taylor (2006), take the positive correlation between price levels and income per capita as evidence of the BS model. Consequently, the BS model has become a standard model in contemporary textbooks of international economics and open macroeconomics. However, our theoretical analysis reveals that the RNHE and BS models are observationally equivalent, which thereby questions the soundness of many important empirical studies on the BS effect. Therefore, this study offers momentous academic value by empirically differentiating the RNHE model from the BS model.

To identify and test the RNHE, we extend the basic RNHE model into a contemporary RNHE model that considers offshore outsourcing and predicts the differences between the price level behaviors of high- and low-income countries.

Specifically, the contemporary RNHE model shows that for high-income countries, the unskilled proportion of the population has a significantly negative impact on the price level even after controlling for per capita income, which is not the case for low-income countries. Our analysis also shows that the per capita income, which is commonly regarded as a proxy for supply-side variables based on the BS model, is in fact a proxy variable on the demand side. Based on the panel data of 130 countries from 1990 to 2010, we empirically confirm such predictions by using the simultaneous equations model. These results are compelling evidence in favor of the RNHE model over the BS model.

This paper is organized as follows. Section 2 discusses the intuitive idea that motivates the RNHE. Section 3 develops a simple model in order to illustrate the basic workings of the RNHE, as opposed to the BS model. Section 4 extends the basic model into a contemporary RNHE model by introducing assumptions that are specific to the current world economy. Section 5 conducts an empirical analysis of the contemporary RNHE model. Section 6 concludes.

2. Motivation for the Basic RNHE Model

The intuition behind the RNHE can be described as follows. Rich countries tend to be those whose population includes a group of "rich residents"; that is, those who obtain high levels (according to some global standard) of hard currency incomes. By "hard currency incomes", we mean cash receipts that are derived from the global market (or other global sources) and largely exogenous to the domestic economy. Rich residents usually own or control some crucial skills, resources, or assets that are in high demand on the global market, such as Silicon Valley IT professionals, French wine producers, Japanese savers/investors, or Persian Gulf oil moguls. However, in fewer instances, they can also be borrowers of foreign capital or recipients of foreign transfers.

These "rich residents" generate demand for local housing and services which, by definition, have to be supplied by their fellow countrymen, who are in most cases less well off and thus might be called the "poor residents". For simplicity, let us first assume (as in our basic model) that the poor residents cannot produce tradables and thus can only make a living by producing housing and services. Then, conceptually, the prices of housing and services in a country can be analyzed by using a simple supply-demand framework. With given preferences, the demand for local housing and services is largely governed by the total purchasing power of the rich residents, which is equal to total tradable sector income in the present case. On the other hand, with fixed technology, the supply of housing and services in a country depends on the population of the poor residents. Therefore, the prices of housing and services in a country are largely determined by the interplay between two variables: 1) the aggregate (tradable sector) income earned by the rich residents, and 2) the population of poor residents. Once the latter variable is given, a high aggregate income of the rich residents will drive the local prices of housing and services to a higher level if an upward-sloping supply curve is assumed. According to this story, a rich country tends to have high prices of housing and services simply because it happens to be a "rich neighborhood", i.e. the country happens to have a group of rich residents whose combined hard currency incomes are large relative to those of the local population.

Equivalently, if we divide the two above variables simultaneously by the total population of the country, the price level of housing and services may also be said to depend on the interplay of 1) the per capita tradable sector income on the demand side, versus 2) the "poor" proportion of the population on the supply side. Assuming that the total tradable sector income is positively related to the national income, then a unique prediction of the RNHE model is that both per capita income and the percentage of poor residents in the total population are important explanators of the price level. According to our analysis, per capita income, commonly regarded as a proxy for supply-side factors based on the BS model, is in fact a proxy variable on the demand side.

3. The Basic RNHE Model

To better differentiate the RNHE, we propose starting from the BS effect, as it is useful to start with a basic model that involves two skill levels.

Imagine a world composed of a large host of small open economies. Suppose each small open economy has a continuum of population of a mass of 1, so that its GDP and per capita GDP are identical. Without loss of generality, we may focus on a representative country i without spelling out the country superscript, while keeping all the other economies in the background.

The population of such a representative economy is divided into two types of agents: unskilled workers of mass U and skilled workers of mass $S = 1-U$. These agents are identical in every aspect except for their skill level, as will be defined in detail below. Thus, an essential assumption of the BS effect is removed, i.e. that of labor force homogeneity. We will assume however that the skilled workers can produce: 1) tradable goods and 2) housing and services. However, in order to highlight the essence of the proposed RNHE and differentiate the RNHE from the BS effect, we will assume in this section that unskilled workers can only produce housing and services. In Section 4, we will relax this assumption by allowing unskilled workers to produce both tradables and housing and services.

There are two goods in this economy: a tradable good X and housing and services Y. Workers make consumption choices according to the following Cobb-Douglas utility function:

$$V = a \log X + b \log Y, \tag{1}$$

where A and B are constant expenditure shares with $a + b = 1$. For Y, housing accounts for a large portion of non-tradable goods and household wealth, especially in the developing countries. For example, about 70 percent of Chinese household wealth is in terms of owning a property.

Following the standard practice, we assume that the law of one price (LOP) holds for X and hereafter use X as the international numeraire (thus $P_X=1$). On the other hand, the local price of Y, which is denoted by P_Y, could potentially differ across countries, and is what we seek to explain.

Both *X* and *Y* are produced with labor as the only input by using constant returns technologies. Each worker inelastically supplies 1 unit of labor service (of his/her own type) for each period of time. As we have assumed above, skilled workers can choose to work either in the *X* or *Y* sector, while unskilled workers can only work in the *Y* sector. We assume that skilled and unskilled workers are equally productive in the *Y* sector. In other words, we assume that a college degree makes little difference if one works as a barber or gardener. The superiority of skilled workers lies in their ability to produce tradables. Specifically, we assume that each skilled worker can produce A_X units of *X* per period and that each worker, whether skilled or unskilled, can produce A_Y units of *Y* per period, where A_X and A_Y are sectoral labor productivity indexes.

The sectoral wage rates are denoted by W_X and W_Y, respectively. In equilibrium, a worker simply earns his/her value product in the corresponding sector. Thus, a skilled worker employed in the *X* sector earns A_X each period and anyone working in the *Y* sector earns $A_Y P_Y$ each period.

Finally, as an equilibrium condition, we assume a balance of trade for each economy, so that the output of each sector must be equal to the demand of that sector.

Now we can proceed to characterize the equilibrium of the economy. We begin by noting that P_Y cannot be greater than A_X/A_Y, because in that case, we have $W_X < W_Y$, so that everyone would choose to work in the *Y* sector and tradable sector output will be zero, which is clearly not an equilibrium. Therefore, we only need to consider two possibilities: 1) "separating equilibrium" where we have $P_Y < A_X/A_Y$ so that $W_X > W_Y$ and all the skilled workers choose to work in the *X* sector, and 2) "pooling equilibrium" where we have $P_Y = A_X/A_Y$ so that $W_X = W_Y$ and some of the skilled workers may work in the *Y* sector.

Let us first consider the "separating equilibrium", where the skilled and unskilled workers are "neatly" divided between the two sectors. To pin down the equilibrium value of P_Y, we carry out the following. We denote the nominal GDP of the economy by y*. Then, we use the constant expenditure shares implied by the Cobb-Douglas preference and the condition that consumption must be equal to output for each sector to obtain:

$$SW_X = SA_X = ay^*, \tag{2}$$

$$UW_Y = UA_Y P_Y = by^* \tag{3}$$

which are combined to arrive at:

$$\frac{UA_Y P_Y}{SA_X} = \frac{b}{a}. \tag{4}$$

The ratio (b/a) is denoted by k. Equation (4) shows that the size of the *Y* sector must be k times that of the *X* sector. Equation (4) is then rearranged to give:

$$P_Y = k\frac{A_X}{A_Y}\frac{S}{U}. \tag{5}$$

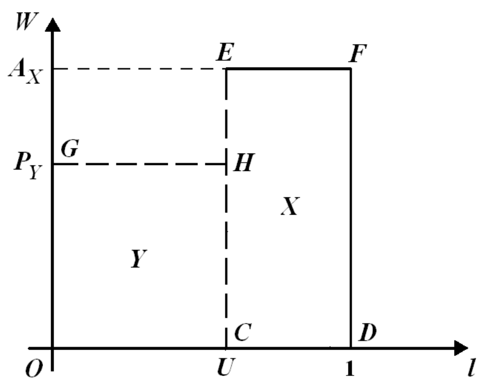
Finally, to ensure consistency for the "separating equilibrium", we assume that the following is true,

$$k\frac{S}{U} < 1. \tag{6}$$

So long as Equation (6) holds, the price level of a country is defined by Equation (5).

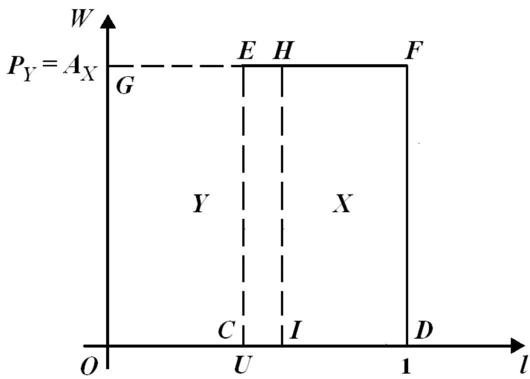
The simple model presented above can also be illustrated with Figure 1, under the additional simplifying assumption that $A_Y = 1$. We index individuals in order of increasing *X*-sector productivity on the interval [0, 1], with the line segment *OC* tracing out the *X*-sector productivity of the unskilled workers (= 0), and the line segment *EF* that of the skilled workers (= A_X). Thus, the total output of the *X* sector is measured by the rectangular area of *EFDC* (= SA_X). Now suppose P_Y is measured by the height of *OG* so that the total output of the *Y* sector is measured by the area occupied by *OGHC* (= UP_Y). Then the equilibrium value of P_Y can be derived from Equation (4), i.e., the area occupied by *OGHC* must be *k* times as large as the area occupied by *EFDC*.

Figure 1 Simple Rich Neighborhood Housing Effect



Now suppose Equation (6) does not hold. In this case, we would have a "pooling equilibrium" with $P_Y = A_X/A_Y$ and wage rates are equalized across the sectors, so that some of the skilled workers may end up working in the *Y* sector. This situation can be similarly analyzed by using Figure 2. Again, we assume that A_Y=1 and line segments *OC* and *EF* represent the *X*-sector productivity of the unskilled and skilled workers, respectively. Suppose the skilled employment of the *Y* sector is represented by the length of *EH* and that of the *X* sector by the length of *HF*. Thus, the output of the *Y* sector is measured by the rectangular area of *OGHI*, i.e. its total employment *GH* times its wage rate $P_Y = A_X$. The output of the X sector is likewise measured by the area occupied by *HFDI*. Now, the shifting variable is no longer P_Y, but rather, the skilled employment of the Y sector (*EH*), in which the equilibrium value is given by the requirement that the sectoral output ratio is equal to the sectoral expenditure ratio k, i.e., that is, the area occupied by *OGHI* must be k times as large as the area occupied by *HFDI*.

Figure 2 Expanded Rich Neighborhood Housing Effect



Now, to relate our results to international price dispersion, let us ignore "pooling equilibrium" as an unrealistic limiting case (where IT engineers work as barbers), and suppose that each small open economy in our hypothetical world corresponds to a particular parameter specification of this basic model. In global equilibrium, Equation (5) indicates that the price level of housing and services in a country is a product of 3 ratios: the preference parameter $k = b/a$, the skilled/unskilled population ratio (S/U), and the tradables/housing and services productivity ratio (A_X/A_Y). Intuitively, the right side of Equation (5), as a combination of demand and supply parameters, measures the scarcity of housing and services relative to the tradables.

More specifically, the right side of Equation (5) can be analyzed into two effects. The first ratio captures the famous Linder effect, i.e. that a greater preference for housing and services over tradables means a higher price level of an economy. The second and the third ratios together imply that a high tradable-sector income relative to the local supply of housing and services will prop up the price level of a country, thus they exactly embody the proposed RNHE.

Furthermore, the aggregate price level of a representative economy is calculated as: [3]

[3] Given the assumed Cobb-Douglas utility function, it is easy to show that the natural price index to use for international price level comparison is $P = P_X^{\ A} P_Y^{\ B} = P_Y^{\ B}$ (note that we assume $P_X = 1$).

$$P = P_X{}^a P_Y{}^b = P_Y{}^b. \tag{7}$$

From Equation (3), the nominal per capita GDP (which is simply y^*) can be written as:

$$y^* = \frac{1}{b} U A_Y P_Y = \frac{1}{b} U A_Y P^{\frac{1}{b}}, \tag{8}$$

So, the real per capita GDP (denoted by y) is

$$y = \frac{y^*}{P} = \frac{1}{b} U A_Y P^{\frac{1-b}{b}} = \frac{1}{b} U A_Y P^{\frac{a}{b}} = \frac{1}{b} U A_Y P^{\frac{1}{k}}. \tag{9}$$

Taking the log on both sides and further rearrangement yield the following equation:

$$\log P = k\left(\log b + \log y - \log U - \log A_Y\right), \tag{10}$$

which predicts that, if cross-national differences in income dominate those in b, U and A_Y, a positive correlation between P and y would show up in the data. Thus, our basic model can also explain for the positive relationship between the price level and income which has been usually addressed by using the BS model.

To sum up, the basic RNHE model is a more general theory of national price levels, which can be contrasted with the BS model in the following aspects. First, the model does not rely on the restrictive assumption of labor force homogeneity as the BS model does, but explicitly allows for a local labor force differentiated by skill level. Second, the BS linkage of intersectoral labor arbitrage and wage equalization is completely severed in our model. Third, our model incorporates the Linder effect as an integral element, but the BS model only as an unlikely limiting case (a "pooling equilibrium"). The price level of housing and services in our model stems from articulated demand and supply conditions.

Finally, as already mentioned, the key explanatory factor of the RNHE is the high hard currency incomes obtained by the "rich residents" of a country, regardless whether these incomes take the form of wages, dividends, or unilateral transfers. For instance, it makes no difference if we replace the skilled workers in the model with a leisurely *rentier* class, each of whom earns an interest income equal to A_X on the international market. Hence, the RNHE model does not have to rely on the tradable sector productivity as the ultimate driving factor, which is the case for the BS effect, and is applicable to a wider variety of circumstances. The RNHE model also incorporates the so-called "Dutch disease" explanation of national price levels, which is beyond the scope of the BS model.[4]

[4] An example of this view is Bourdet and Falck (2006), who find that, during the 1990s, the real exchange rate in Cape Verde appreciated by 14% as local incomes rose with a doubling of remittances from abroad.

An interesting question in this case is to ask: how can we differentiate the RNHE model from the BS model? Both of these models can explain for the positive relationship between price level and income. Since Balassa (1964), many empirical studies, such as Heston, Nuxoll and Summers (1994), Cihak and Holub (2001), and Bergin, Glick, and Taylor (2006), treat the positive correlation between price levels and income per capita as evidence of the BS effect. The RNHE model shows a certain degree of observational equivalence with the BS model, which may prevent the econometric models proposed in the literature from identifying the RNHE and BS effects. The RNHE model merely observes a positive correlation between price levels and income per capita, and such correlation does not suggest the existence of the BS effect. Therefore, many empirical studies that offer evidence to support the BS model may also generate observations that favor the RNHE model.

To empirically differentiate the RNHE model from the BS model, we extend the basic RNHE model into a contemporary RNHE model.

4. The Contemporary RNHE Model

The basic model presented in Section 3, although useful for bringing out the gist of the RNHE, does not square perfectly with commonsense observations of the present day world, in that it assumes only skilled workers will work in the tradable sector. This assumption may be reasonably true for today's OECD economies, which have become gradually "dis-industrialized" since the 1980s. However, throughout the developing world, labor-intensive tradable industries are thronged with people whom we normally classify as "unskilled workers".

To remedy this problem, in this section we will extend the basic RNHE model into a contemporary model by incorporating a crucial element of the modern world economy, i.e., outsourcing. Admittedly, the current economic globalization process has been marked by the dramatic expansion of outsourcing or "processing trade". Since the 1970s, trade openings in developing countries and advances in transport and communication technologies have made it increasingly profitable to split the production process into discrete stages and spread them across different countries.

According to Grossman and Rossi-Hansberg (2008), outsourcing represents a profound change in the nature of international trade. They conceptualize the production process as a set of tasks. Each task requires the input of some single factor of production. Under the traditional Heckscher-Ohlin (H-O) model, countries are supposed to trade in goods. Under outsourcing, countries trade in tasks. Tang (2012) builds upon this idea and develops a calculable general equilibrium model to explain how manufacturing outsourcing between the North and the South affects good and factor prices in the North. Following the modeling strategy in Tang (2012), we modify our basic model as follows.

Let us now assume that the X sector uses a Leontief technology that involves performing two types of tasks in a fixed proportion, which, without loss of generality, can be described by the following production function:

$$X = f(X_S, X_U) = \min\{X_S, X_U\} \tag{11}$$

where X_S and X_U denote the amount of "skilled" and "unskilled" tasks, respectively. We further assume that X_S can only be performed by skilled labor, while X_U can be performed by both skilled and unskilled labor with equal efficiency.

Both X_S and X_U are performed or "produced" under linear production functions with fixed yet country-specific labor productivity which potentially varies across countries. We also assume that, for every country, the skilled wage rate is higher than the unskilled wage rate, so that firms will only hire unskilled labor for performing unskilled tasks. Thus, for a representative country i, we have:

$$X_S^i = A_{XS}^i S_X^i, \qquad X_U^i = A_{XU}^i U_X^i \tag{12}$$

where A_{XS} and A_{XU} denote the labor productivity for performing skilled and unskilled tasks, respectively, while S_X and U_X are skilled and unskilled employment of the X sector, respectively. The letter i is the country superscript. We maintain all the assumptions of our basic model except for the above modifications that concern the X sector. Again, so long as no confusion arises, we will discuss a representative country while suppressing the country superscript.

Now, it is crucial to realize the profound changes in the economic environment brought about by outsourcing. Prior to the 1980s, trade in manufactures was mainly conducted as trade in *goods*, in that the skilled and unskilled tasks that compose a final manufacturing good were usually performed in the same country and thus bear the same country superscript. However, since then, it has gradually become routine for multinational corporations to deploy the skilled and unskilled tasks that compose their final products in different countries, in an aggressive attempt to arbitrage on cross-national differences in both skilled and unskilled wages, after allowing for productivity differences and additional expenses such as transportation costs. For example, Feenstra (1998) observes that,

> "*…both Mattel and Nike do the design and marketing of their products in the United States. The [unskilled] activities outsourced [to other countries] by these corporations are part of their larger 'value chain'*"

In his immensely popular book *The World Is Flat: A Brief History of the Twenty-first Century*, Friedman (2005, p.124) writes,

> "*Most surprisingly, ASIMCO [an auto parts manufacturer] will use its new camshaft operation in China to handle the raw material and rough machining operations, exporting semi-finished products to its camshaft plants in America, where more skilled American workers can do the finished machining operations, which are most critical to quality*"

The manufacturing trade induced by such "disintegration of production", whether in the form of intermediate inputs (as in the case of ASIMCO above) or finished products [5] (as when China exports a Nike shoe to the USA), is in fact trade in *tasks*. In both cases, China is exporting only the unskilled tasks that go into the final good.

The implications of this great transformation in terms of our modified model are threefold. First, the LOP now applies not only to the final good X, as under the traditional H-O model, but also to the skilled and unskilled tasks that make up the good X, i.e. X_S and X_U. Second, any country can "produce" and export either X_S or X_U or both, so long as it is cost-competitive vis-à-vis other countries to do so. Third, the outputs as well as the exports of X_S and X_U of any single country need not bear any proportional relationship to each other, as is required by the Leontief production function (Equation (11)) under the traditional H-O model, although for the world as a whole, the total outputs of X_S and X_U must be equal as per Equation (11).

With these caveats in mind, we can go on to characterize the equilibrium of our modified model. It is obvious that under the present setting, unskilled workers can potentially end up either working in the Y sector or performing unskilled tasks in the X sector. Moreover, with the additional assumption that the skilled wage rate is higher than the unskilled wage rate for every country, skilled workers will only be doing the skilled tasks in the X sector.

In light of the basic mechanism of the RNHE as presented in Section 3, it is easy to imagine two possible equilibrium scenarios in this modified model, which we may call the high-income scenario and the low-income scenario, respectively. The high-income scenario corresponds to the OECD economies; because these countries are endowed with a proportionally large and highly productive skilled population, they have a strong RNHE, and thus their prices of housing and services and unskilled wages will be high. On the other hand, the low-income scenario applies to the less developed economies where the skilled population is proportionally small, thus resulting in a weak RNHE and relatively low prices of housing and services and unskilled wages. Let us suppose that the labor productivity for producing the unskilled tasks in the X sector is only slightly different across countries.[6] Thus, high-income countries will not be able to compete with low-income countries for the unskilled tasks in the X sector and will lose their "blue-collar" jobs to the latter once these tasks can be "outsourced". In fact, this is exactly why dis-industrialization in the OECD countries has coincided with the era of outsourcing. Therefore, two groups of countries may be differentiated by the unskilled employment in the X

[5] This is why we choose to identify outsourcing as "trade in tasks" rather than as "trade in intermediate inputs" even though the latter usage is more popular.
[6] This is a reasonable assumption given the fact that multinational corporations tend to use similar technologies for their (unskilled) labor intensive production operations in different countries.

sector in global equilibrium, which will be zero for high-income countries, but positive for low-income countries.

The exact analytical solution of the model is derived as follows. Given that the LOP holds for X_S and X_U, i.e., the skilled and unskilled tasks in the X sector, we may denote their international prices as P_{XS} and P_{XU}, respectively. Both P_{XS} and P_{XU} are assumed to be taken as given by all of the countries. In other words, we retain the small country assumption. For simplicity, we now set X_S as the international numeraire, so that $P_{XS} = 1$. Moreover, the LOP should also hold for the good X, with $P_X = P_{XS} + P_{XU} = 1 + P_{XU}$ by virtue of the Leontief production function (Equation (11)). However, P_Y can still vary across countries, thus resulting in international price level differences.

The equilibrium solution for the high-income scenario is straightforward. Since skilled workers only work in the X sector and unskilled workers only in the Y sector, this reduces to our basic model. For a representative high-income country, its X- and Y-sector outputs are $A_{XS}S$ and $P_Y A_Y U$, respectively. Again, the equilibrium price level of housing and services is given by the condition that the sectoral output ratio is equal to the sectoral consumption ratio:

$$\frac{P_Y A_Y U}{A_{XS} S} = \frac{b}{a} = k \Rightarrow P_Y = k \frac{A_{XS}}{A_Y} \frac{S}{U} \tag{13}$$

The low-income scenario is more complicated, where some unskilled workers are doing the unskilled tasks in the X sector. For a representative low-income country, let us denote the unskilled employment of its X and Y sectors by using U_X and U_Y, respectively, where $U_X + U_Y = U$. Then its X- and Y-sector outputs are $(A_{XS}S + P_{XU} A_{XU} U_X)$ and $P_Y A_Y U_Y$, respectively. Since the price of unskilled tasks in the X sector P_{XU} is determined in the world market, the unskilled wage rate of the X sector is simply $P_{XU} A_{XU}$, while that of the Y sector is $P_Y A_Y$. The condition that the unskilled wage rate should be uniform across the X and the Y sectors yields the equilibrium price level of housing and services,

$$P_Y = \frac{A_{XU}}{A_Y} P_{XU} \quad . \tag{14}$$

This result is very similar to that of the BS model. To fully define the low-income equilibrium, the equilibrium values of U_X and U_Y are implicitly defined by the condition that the sectoral output ratio is equal to the sectoral consumption ratio:

$$\frac{P_Y A_Y U_Y}{A_{XS} S + P_{XU} A_{XU} U_X} = \frac{P_{XU} A_{XU} U_Y}{A_{XS} S + P_{XU} A_{XU} U_X} = k \quad . \tag{15}$$

To ensure consistency, we must impose the condition that it is not cost-competitive for high-income countries to perform unskilled tasks in the X sector. In other words, we must have

$$P_Y A_Y = k A_{XS} \frac{S}{U} > P_{XU} A_{XU} \Rightarrow \frac{S}{U} > \frac{1}{k} \frac{A_{XU}}{A_{XS}} P_{XU} \quad , \tag{16}$$

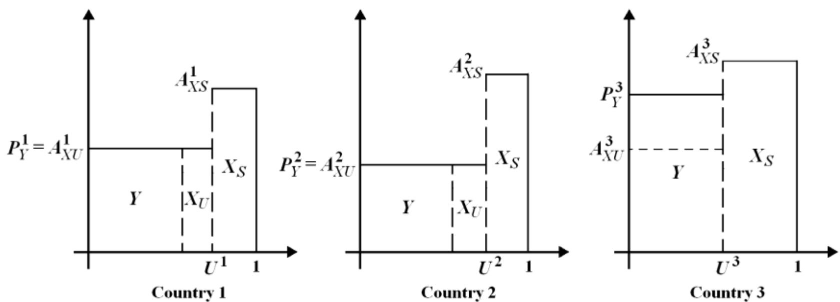
which essentially requires that the skilled/unskilled population ratio to be large enough so that there is a strong RNHE to sustain a high wage rate in the Y sector. Similarly, the opposite condition must hold for the low-income countries:

$$\frac{S}{U} \leq \frac{1}{k} \frac{A_{XU}}{A_{XS}} P_{XU} \ . \tag{17}$$

Finally, the only remaining loose piece in our model is the equilibrium value of P_{XU}. Obviously, as this price increases, the total world output of X_U will increase and some marginally high-income countries will turn into low-income ones, and vice versa. Global equilibrium is defined by the condition in which the value of P_{XU} is such that the total world output of X_S is equal to that of X_U as per Equation (11). This completes the equilibrium characterization of the model.

The global equilibrium of this modified model is illustrated in Figure 3, under the additional simplifying assumption that $k = 1$, $P_{XU} = 1$, and $A_Y^i = 1$ for all i. Thus, for the two low-income countries depicted in the graph, i.e. Countries 1 and 2, we have $P_Y^i = A_{XU}^i$. For the high-income countries, that is, Country 3 in the graph, P_Y^i is derived by the condition that the Y/X sectoral output ratio is equal to 1, as in Figure 1. On the other hand, for the low-income countries, the shifting variable that adjusts to satisfy this sectoral output ratio requirement is X_U, i.e., the amount of unskilled tasks performed in the X sector.

Figure 3 Contemporary Rich Neighborhood Housing Effect



In summary, the contemporary RNHE model presented above portrays a picture of international price dispersion that is intrinsically different and far more complicated than the BS model. The model predicts that two categories of countries will emerge in global equilibrium, depending on the relative strength of the RNHE in each country vis-à-vis that in others. For the low-income countries, the relevant determining variable is not the average labor productivity of the tradable sector as the BS model predicts, even though the price level is governed by an intersectoral labor arbitrage condition akin to the BS linkage, but rather the productivity of unskilled labor in the tradable sector. Moreover, the RNHE is the overarching mechanism that implicitly defines the equilibrium for these countries (note that it is the RNHE that draws the borderline between the two groups in the first place). For the high-income countries, however, the BS linkage of intersectoral labor arbitrage is completely severed, i.e. the prices of housing and services no longer bear any simple relationship to tradable-sector productivity. Furthermore, this dichotomy between the two categories is only relative and not fixed. That is, as the international price of "outsourceable" unskilled tasks in the tradable sector changes in response to supply-demand conditions, countries that border between the two groups might switch sides from time to time.

It is important to point out that housing is not outsourceable. Therefore, housing price is a key driving force of the price difference between rich and poor countries in the contemporary RNHE model.

5. Empirical Analysis of the Contemporary RNHE Model

5.1 Testable Hypotheses

The RNHE model is theoretically more general than the BS model. As such, can we empirically differentiate the RNHE model from the BS model by using actual data and demonstrate that the RNHE model is more realistic than the BS model? The contemporary RNHE model suggests the following testable hypotheses.

1) High- and low-income countries show different national price level behaviors in relation to the income and skill structures of their population.
2) Price level is positively correlated with income per capita for both high- and low-income countries.
3) For high-income countries, the unskilled proportion of the labor force *U* has a significantly negative relationship with price level even after controlling for income per capita. However, this relationship is not significant for low-income countries.

If the three above testable hypotheses are confirmed，we can say that our model can explain for the real world in such a detailed way that the BS model cannot, which is compelling evidence in favor of our model. Furthermore, given that *U* is a direct measure of the heterogeneity of the local labor force, we take the third corollary as a counterevidence against the BS model, which rests on the assumption of a uniform local labor force.

First, we subject our contemporary RNHE model to an intuitive check. Merging Penn World Table (PWT) 8.0 and BL2.0 in Barro and Lee (2010) leaves us with an effective sample size of 130 countries, which contains three variables: national price level *P*, income per capita *y*, and the unskilled proportion of the labor force *U*. Moreover, since the available World Bank country classification data only extends back to 1987 and the BL2.0 is reported at five-year intervals, there are in total 5 years for which we have all of the necessary data, i.e. 1990, 1995, 2000, 2005, and 2010.

A further question concerns the criterion for sorting the sample into high-income vs. low-income subsamples. As we discussed in the previous section, the high-income countries in our model experientially correspond to the rich developed economies which are no longer competitive in unskilled labor-intensive tradable industries, while the low-income countries correspond to the relatively poor developing countries where these industries can still flourish. The World Bank routinely publishes a document called List of Economies that classifies countries into high-income, middle-income and low-income economies according to the World Bank measure of their real per capita income (unlike similar measures in PWT8.0) on a yearly basis, with the official understanding that "low-income and middle-income economies are sometimes referred to as developing economies" (The World Bank website[7]). Hence, the simple choice is to follow the classification scheme of the World Bank. Specifically, any country that is classified by the World Bank as a high-income economy is sorted into the high-income subsample; otherwise, it is sorted into the low-income subsample.

It is worth noting that the practice of dividing countries into two groups by income when discussing national price levels does not begin with us. In his influential study, Rogoff (1996) observes that "whereas the relationship between income and prices is quite striking over the full data set, it is far less impressive when one looks either at the rich (industrialized) countries as a group, or at developing countries as a group". In light of our model, this fact is easy to explain, because within each country group, income differences are not large enough to dominate the differences in U_Y, which coincides with U for the rich country group.

Figures 4 and 5 show the corresponding bivariate scatterplots of three variables (price level P, income per capita y, and unskilled proportion of the labor force U) in pooled data from 1990–2010 and cross-sectional data from 2010. P and y are positively correlated for both the high- and low-income country groups.[8] P is negatively correlated with U for the high-income country group, but not for the low-income country group. The results from the intuitive check are consistent with the theoretical expectation of the contemporary RNHE model. However, these results cannot be used as evidence to support the RNHE model. Therefore, we adopt the simultaneous equations model to test the contemporary RNHE model.

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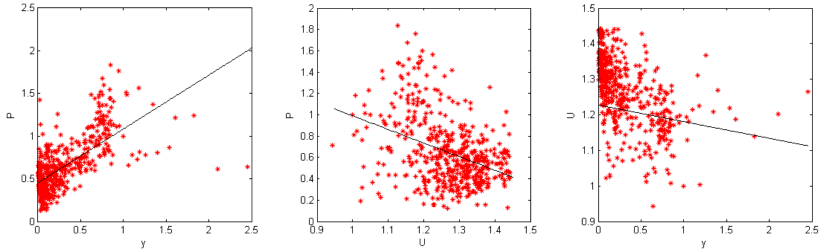
[7] https://datatopics.worldbank.org/world-development-indicators/stories/the-classification-of-countries-by-income.html

[8] We adopt the World Bank 2000 division of high- and low-income countries in our pooled data for 1990–2010 and the World Bank 2010 division in the cross-sectional data for 2010.

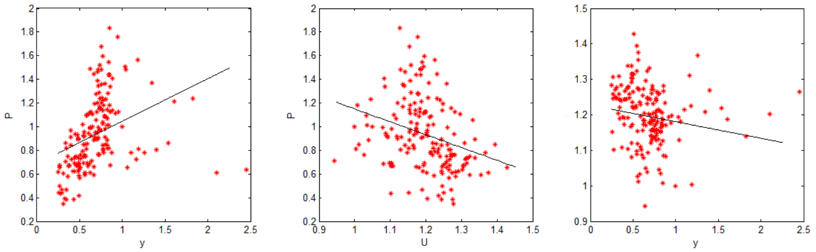
Figure 4 Scatterplots of Pooled Data: 2000-2010

(1) Entire Sample



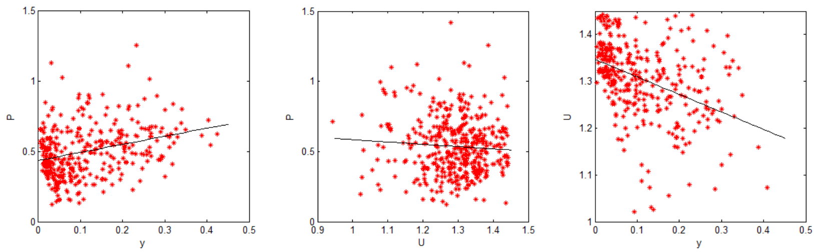
P vs. *y* *P* vs. *U* *U* vs. *y*

(2) High-Income Subsample



P vs. *y* *P* vs. *U* *U* vs. *y*

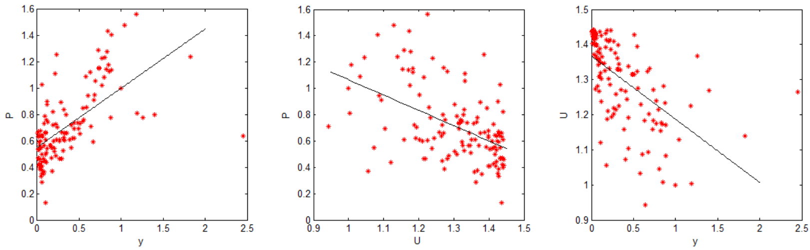
(3) Low-Income Subsample



P vs. *y* *P* vs. *U* *U* vs. *y*

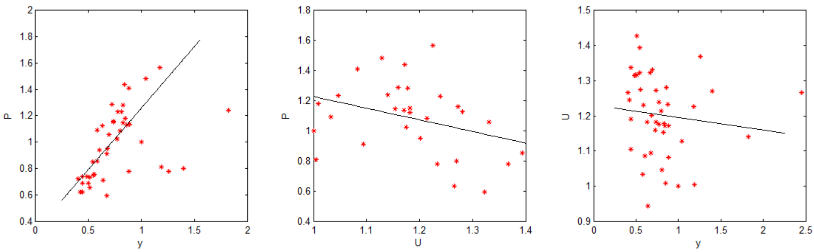
Figure 5 Scatterplots of Variables: 2010

(1) Entire Sample



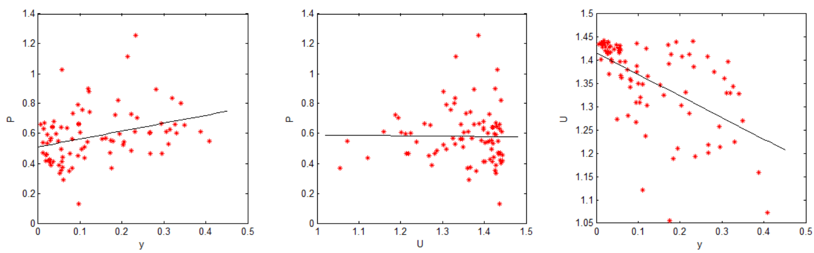
P vs. *y* *P* vs. *U* *U* vs. *y*

(2) High-Income Subsample



P vs. *y* *P* vs. *U* *U* vs. *y*

(3) Low-Income Subsample



P vs. *y* *P* vs. *U* *U* vs. *y*

5.2 Structural System of Simultaneous Equations

Without loss of generality, we can redefine the final good *X* as the international numeraire in the contemporary model as discussed in Section 4. As in Section 3, for any representative country *i*, we may suppress the country superscript and write its aggregate price level as

$$P = P_X{}^a P_Y{}^b = P_Y{}^b. \tag{18}$$

Likewise, its nominal per capita GDP can be written as:

$$y^* = \frac{1}{b} P_Y Y = \frac{1}{b} P_Y A_Y U_Y = \frac{1}{b} P^{\frac{1}{b}} A_Y U_Y, \tag{19}$$

where U_Y is the Y-sector employment. Again, the real per capita GDP is calculated as:

$$y = \frac{y*}{P} = \frac{1}{b} P^{\frac{1-b}{b}} A_Y U_Y = \frac{1}{b} P^{\frac{a}{b}} A_Y U_Y = \frac{1}{b} P^{\frac{1}{k}} A_Y U_Y . \tag{20}$$

Taking the log on both sides and rearranging the equation result in:

$$\log P = k\left(\log b + \log y - \log U_Y - \log A_Y\right), \tag{21}$$

which is the structural equation that we seek to estimate.

A standard source of panel data on P and y is the Penn World Tables. We choose to use PWT8.0, which reports yearly adjusted price levels of purchasing power parity (PPP) and income measures for 167 countries from 1950-2011. Unfortunately, good quality data on A_Y (labor productivity in the housing and services sector) or U_Y (employment in the housing and services sector) are not available. However, according to our theoretical model, U_Y coincides with U, the unskilled proportion of the population for the high-income countries. Therefore, for these countries, Equation (21) can be rewritten as:

$$\log P = k\left(\log b + \log y - \log U - \log A_Y\right). \tag{22}$$

Moreover, Barro and Lee (2010) provide comprehensive country-level panel data on the educational attainment of the population at five-year intervals from 1950-2010, the newest version of which is BL2.0. Since it is common practice to associate skilled workers with at least a college education, we take the percentage of the population who are 25 years old and over and completed tertiary education reported in BL2.0 as a direct measure for S (the skilled proportion of the population). Subtracting this measure from 1 yields a direct measure for U. On the other hand, it is clear from Equation (15) that, for a low-income country, U_Y has no simple linear relationship with U, as it is influenced by several other country-specific parameters such as A_{XU}, A_{XS}, etc. Thus Equation (22) does not apply to low-income countries.

Equation (22) is an endogenous correlation expression that cannot be depicted with the traditional single equation econometric model. Therefore, we construct a system of simultaneous equations for our empirical study. In this system, P, y, and U are treated as endogenous variables, and A_Y is subsumed in the error term. Given that we use panel data, the system of simultaneous equations is constructed as follows:

$$\begin{cases} \log P_{it} = \alpha_0 + \alpha_1 \log y_{it} + \alpha_2 \log U_{it} + \sum_{j=3}^{k_1} \alpha_j X_{jit} + \delta_i + \eta_t + e_{it} \\ \log y_{it} = \beta_0 + \beta_1 \log P_{it} + \sum_{j=2}^{k_2} \beta_j Y_{jit} + \delta_i + \eta_t + \varepsilon_{it} \\ \log U_{it} = \gamma_0 + \gamma_1 \log P_{it} + \sum_{j=2}^{k_3} \gamma_j Z_{jit} + \delta_i + \eta_t + \xi_{it} \end{cases} \tag{23}$$

where the subscripts i and t denote country and year, respectively. P_{it} and y_{it} are, respectively, PPP adjusted price level and real per capita GDP calculated from PWT8.0, and expressed in relative terms to the US values in 2005 (USA in 2005 = 1).[9] U_{it} (which ranges between 0 and 1) is the percentage of the population who are 25 years old and over and have NOT completed tertiary education, which is calculated from BL2.0. X_{jit}, Y_{jit}, and Z_{jit} are control variables that control the effects of other factors on the dependent variables, δ_i and η_t which denote individual and time effects, respectively, and e_{it}, ε_{it}, and ξ_{it} are independent and identically distributed error terms.

The theoretical analysis reveals that if the contemporary RNHE model holds true, then we achieve the following results when estimating the system of simultaneous equations. First, in the high-income subsample, the coefficients α_1 and β_1 must be significantly positive, while α_2 and γ_1 must be significantly negative. Second, in the low-income subsample, the coefficients α_1 and β_1 must be significantly positive, while γ_1 must be insignificant.

5.3 Data Description

We obtain the variables for our empirical study by merging PWT8.0, BL2.0, and the World Bank Database. According to the system of simultaneous equations, the control variables are introduced into the equations to eliminate the influence of national economic and social development on each dependent variable except for the endogenous variables *P*, *y*, and *U*. These control variables may also influence the dependent variables. First, the population density, container port traffic per capita, energy self-sufficiency rate, arable land per capita, and average price level in foreign countries of this region are introduced in the price level equation. Second, capital formation per capita, R&D expenditure per capita, energy use per capita, urbanization rate, industrial structure, and foreign direct investment (FDI) per capita are introduced in the income equation. Third, poverty headcount ratio, industrial structure, and urbanization rate are introduced in the unskilled labor force equation. All variables are expressed relative to their US values in 2005 (USA in 2005 = 1). Table 1 provides the definition and measurement of each variable.

Table 1 Definition and Measurement of Variables

Symbol Variable	Measurement
Endogenous Variables	

[9] *P* corresponds to the variable "pl_gdpe" (price level of expenditure-side GDP) in PWT8.0, while *y* is derived by dividing "cgdpe" (expenditure-side real GDP at current PPPs) by "pop" (population). Both are further divided by the corresponding US values in 2005 to be on a magnitude comparable to *U*, i.e. around 1.

P	National price level	PPP-adjusted national price level calculated from PWT8.0.
y	Income per capita	Real GDP per capita calculated from PWT8.0.
U	Unskilled proportion of the labor force	Percentage of the population who are 25 years old and above and have not completed tertiary education calculated from BL2.0.
Control Variables		
POD	Population density	People per sq. km of land area
RG	Container port traffic per capita	Container port traffic (TEU: 20 foot equivalent units).
EIN	Energy self-sufficiency rate	Ratio between national primary energy output and consumption of primary energy.
RL	Arable land per capita	Arable land (hectares per person).
PREG	Average price level of foreign countries in this region	Average price level of foreign countries in this region. The regions include North America, South America and the Caribbean, Oceania, East Asia, Southeast Asia, South Asia, West Asia and North Africa, Eastern Europe and Central Asia, West Europe, and Sub-Saharan Africa.
RC	Capital formation per capita	Capital formation per capita calculated according to the 1993 System of National Accounts (SNA) standard.
RRD	R&D expenditure per capita	Research and development expenditure per capita.
UR	Urbanization rate	The ratio of urban population to total population.
RE	Energy use per capita	Energy use (kg of oil equivalent per capita).
INDS	Industrial structure	The ratio of industry value added to GDP.
RFDI	FDI per capita	FDI per capita (balance of payment (BoP), current US$).
PUR	Poverty headcount ratio	Poverty headcount ratio at national poverty lines (% of population).

***Notes*:** All variables are expressed relative to their US values in 2005 (USA in 2005 = 1). The original data for the control variables are obtained from the World Bank Database.

5.4 Estimation Results of the System of Simultaneous Equations

According to the corollaries of the contemporary RNHE model, we divide our sample into high- and low-income subsamples when estimating the system of simultaneous equations. These subsamples follow the 2000 classification scheme of the World Bank. Generally, both the two- (2SLS) and three-stage least squares (3SLS) methods provide consistent estimations for the system of simultaneous equations. Given that 3SLS considers the inter-temporal (rather the simultaneous) correlations between error terms, the efficiency and validity of the parameters estimated by the 3SLS method are superior to those estimated by the 2SLS method. Therefore, we adopt the 3SLS method to estimate the system of simultaneous equations. Table 2 shows the detailed results of the estimation.

As reported in Table 2, the predictions of the contemporary RNHE model on the differences between the price level behaviors of high- and low-income countries are confirmed by statistical data, thereby offering compelling evidence to support the empirical relevance of our model. For the entire sample, and the high-income and low-income subsamples, the estimation coefficients of $\log(y)$ in the price equation are 0.277, 0.145, and 0.351, respectively, which are all significant at the 5% level, while the estimation coefficients of $\log(P)$ in the income equation are 0.302, 0.403, and 0.255, respectively, which are also significant at the 5% level. These results indicate a significantly positive relationship between price level and income per capita after controlling for other factors. For the high-income subsample, the estimated coefficient of $\log(U)$ in the price equation and the estimated coefficient of $\log(P)$ in the unskilled labor force equation is –0.366 and –0.422, respectively, which are both significant at the 1% level. However, for the low-income subsample, the estimated coefficient of $\log(U)$ in the price equation and the estimated coefficient of $\log(P)$ in the unskilled labor force equation are both insignificant with relatively small absolute values (–0.131 and –0.213, respectively). Therefore, the unskilled proportion of the population has a significantly negative relationship with the price level in high-income countries compared to low-income ones even after controlling for income. In sum, the regression results of the system of simultaneous equations indicate that the theoretical predictions of the contemporary RNHE model for 1990 to 2010 hold true by dividing the sample into high- and low-income subsamples in accordance with the 2000 classification scheme of the World Bank.

Table 2 Estimation Result of Contemporary RNHE Model: 1990-2010

Variable	Entire sample			High-income subsample			Low-income subsample		
	log(*P*)	log(*y*)	log(*U*)	log(*P*)	log(*y*)	log(*U*)	log(*P*)	log(*y*)	log(*U*)
Intercept	0.845***	-0.471***	0.228	0.664	-0.355***	0.441**	0.655***	-0.130	-0.106
	(0.287)	(0.119)	(0.514)	(0.662)	(0.118)	(0.219)	(0.124)	(0.293)	(0.066)
log(*P*)		0.302**	-0.278		0.403***	-0.422***		0.255**	-0.213
		(0.134)	(0.196)		(0.068)	(0.075)		(0.105)	(0.207)
log(*y*)	0.277***			0.145**			0.351***		
	(0.034)			(0.063)			(0.062)		
log(*U*)	-0.282			-0.366***			-0.131		
	(0.322)			(0.064)			(0.112)		
log(*POD*)	0.025**		0.130**	0.071***		0.122*	0.018***		0.489***
	(0.012)		(0.057)	(0.028)		(0.071)	(0.007)		(0.077)
log(*RG*)	-0.016**			-0.054***			-0.012**		
	(0.008)			(0.011)			(0.006)		
log(*EIN*)	-0.031			-0.016			-0.057**		
	(0.029)			(0.031)			(0.021)		
log(*RL*)	-0.141			-0.110			-0.202***		
	(0.511)			(0.618)			(0.059)		
log(*PREG*)	0.291***			0.522***			0.228***		
	(0.081)			(0.189)			(0.049)		
log(*RC*)		0.203***			0.287***			0.199***	
		(0.059)			(0.109)			(0.027)	

(*Continued…*)

(Table 2 Continued)

Variable	Entire sample			High-income subsample			Low-income subsample		
	log(*P*)	log(*y*)	log(*U*)	log(*P*)	log(*y*)	log(*U*)	log(*P*)	log(*y*)	log(*U*)
log(*RRD*)		0.018			0.076*			-0.016	
		(0.012)			(0.038)			(0.074)	
log(*UR*)		0.357**	-0.322**		0.383	-0.301		0.128***	-0.339***
		(0.142)	(0.131)		(0.512)	(-0.198)		(0.046)	(0.088)
log(*RE*)		0.188*			0.205***			0.192***	
		(0.119)			(0.071)			0.055	
log(*INDS*)		0.007	-0.151		-0.012	0.115		0.012	-0.286**
		(0.008)	(0.502)		(0.009)	(0.771)		(0.021)	(0.135)
log(*RFDI*)		0.178*			0.121***			0.149*	
		(0.101)			(0.046)			(0.082)	
log(*PUR*)			0.198***			0.299***			0.281**
			(0.061)			(0.094)			(0.117)
Individual Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	650	650	650	170	170	170	480	480	480
adj. R^2	0.547	0.291	0.354	0.572	0.485	0.262	0.689	0.530	0.463

Notes: the high- and low-income subsamples are sorted by following the 2000 classification scheme of the World Bank. The numbers in brackets are standard errors. *, ** and *** denote significance higher than 0.1, 0.05 and 0.01, respectively. The same applies hereinafter.

In the system of simultaneous equations, most of the estimated coefficients of the control variables are significant, thereby supporting the setting of the empirical model to some extent. Other factors apart from the RNHE can also affect price level, income per capita, and unskilled proportion of the population. First, the performance of the control variables in the price equation is consistent with general knowledge. For both the high- and low-income subsamples, population density and average price level in foreign countries of this region have a significantly positive influence on price level, while container port traffic per capita, which reflects traffic and trade openness, has a significantly negative influence on price level. For the low-income subsample, energy self-sufficiency rate and arable land per capita have a significantly negative influence on price level. Second, the performance of the control variables in the income and unskilled labor force equations coincides with general economics knowledge. For both the high- and low-income subsamples, capital formation per capita, R&D expenditure per capita, and energy use per capita have a significantly positive influence on income per capita. For the low-income subsample, urbanization rate and industrial structure have a significant influence on the unskilled proportion of the population, while for the high-income subsample, poverty headcount ratio has a significant influence on the unskilled proportion of the population.

5.5 Robustness Analysis

To ensure the robustness of our core conclusions, we estimate two additional specifications.

Given that our sample period covers the years 1990 to 2010, we adopt the 2000 (median year) classification scheme of the World Bank to divide our sample into high- and low-income subsamples. However, the classification of high- and low-income countries varied throughout the sample period. According to the World Bank standard, 11 countries have been reclassified from low-income to high-income countries.[10] After excluding these countries, we re-estimate the system of simultaneous equations by using the 3SLS method to eliminate the potential errors that result from the reclassification. Table 3 presents the detailed results.

The sign and significance of the estimated coefficients of the endogenous (log(P), log(y), and log(U)) and control variables in Table 3 are in accordance with those in Table 2. Most of the adjusted R^2 values have increased after excluding the 11 countries that have been reclassified from low- to high-income countries. These results further validate the robustness and ability of the contemporary RNHE model to reflect real world conditions.

[10] These 11 countries (regions) include Bahrain, Barbados, Macao, Greece, Hungary, Malta, Poland, Portugal, the Republic of Korea, Saudi Arabia, and Trinidad and Tobago. The remaining countries have maintained the same income levels throughout the sample period.

Table 3 Robustness Check of the Contemporary RNHE model: 1990-2010

Variable	Entire sample			High-income subsample			Low-income subsample		
	log(*P*)	log(*y*)	log(*U*)	log(*P*)	log(*y*)	log(*U*)	log(*P*)	log(*y*)	log(*U*)
Intercept	0.859***	-0.492***	0.201	0.627	-0.372**	0.461*	0.700***	-0.141	-0.171***
	(0.298)	(0.106)	(0.471)	(0.629)	(0.147)	(0.231)	(0.093)	(0.339)	(0.066)
log(*P*)		0.276**	-0.314		0.506***	-0.433***		0.288***	-0.169
		(0.140)	(0.237)		(0.055)	(0.077)		(0.091)	(0.201)
log(*y*)	0.300***			0.223***			0.441***		
	(0.041)			(0.071)			(0.031)		
log(*U*)	-0.295			-0.384***			-0.119		
	(0.279)			(0.043)			(0.126)		
log(*POD*)	0.038*		0.163***	0.061***		0.079**	0.004		0.453***
	(0.023)		(0.034)	(0.024)		(0.035)	(0.005)		(0.070)
log(*RG*)	-0.064***			-0.082***			0.028		
	(0.018)			(0.009)			(0.033)		
log(*EIN*)	-0.063			0.004			-0.085***		
	(0.047)			(0.049)			(0.027)		
log(*RL*)	-0.111			-0.121			-0.163***		
	(0.553)			(0.663)			(0.016)		
log(*PREG*)	0.302**			0.534***			0.190***		
	(0.129)			(0.208)			(0.068)		
log(*RC*)		0.227**			0.288**			0.217***	
		(0.108)			(0.133)			(0.031)	

(*Continued…*)

(Table 3 Continued)

Variable	Entire sample			High-income subsample			Low-income subsample		
	log(*P*)	log(*y*)	log(*U*)	log(*P*)	log(*y*)	log(*U*)	log(*P*)	log(*y*)	log(*U*)
log(*RRD*)		0.002			0.007			-0.013	
		(0.037)			(0.007)			(0.097)	
log(*UR*)		0.305***	-0.365**		0.366	-0.270		0.175***	-0.368***
		(0.109)	(0.155)		(0.505)	(0.191)		(0.043)	(0.052)
log(*RE*)		0.173**			0.246***			0.142	
		(0.086)			(0.033)			(0.095)	
log(*INDS*)		0.044	-0.122		0.037	0.092		0.004	-0.271***
		(0.032)	(0.529)		(0.029)	(0.745)		(0.046)	(0.099)
log(*RFDI*)		0.176**			0.160**			0.121**	
		(0.072)			(0.077)			(0.052)	
log(*PUR*)			0.154**			0.274***			0.326**
			(0.076)			(0.085)			(0.132)
Individual Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	595	595	595	150	150	150	440	445	445
adj. R^2	0.613	0.352	0.162	0.748	0.455	0.314	0.772	0.580	0.360

Note: excluding the 11 countries that have been reclassified from low- to high-income countries from 1990 to 2010.

Table 4 Robustness Check of the Contemporary RNHE model: Cross-Section 2010

Variable	Entire sample			High-income subsample			Low-income subsample		
	log(*P*)	log(*y*)	log(*U*)	log(*P*)	log(*y*)	log(*U*)	log(*P*)	log(*y*)	log(*U*)
Intercept	0.810**	-0.444***	0.223	0.690	-0.359***	0.393*	0.694***	-0.178	-0.082
	(0.266)	(0.162)	(0.542)	(0.708)	(0.125)	(0.205)	(0.125)	(0.340)	(0.100)
log(*P*)		0.320***	-0.239		0.466***	-0.442***		0.251*	-0.168
		(0.086)	(0.188)		(0.116)	(0.059)		(0.151)	(0.178)
log(*y*)	0.305***			0.117*			0.565***		
	(0.006)			(0.061)			(0.101)		
log(*U*)	-0.291			-0.323***			-0.092		
	(0.360)			(0.079)			(0.153)		
log(*POD*)	0.035		0.081	0.105***		0.164	-0.004		0.531***
	(0.028)		(0.056)	(0.023)		(0.113)	(0.048)		(0.080)
log(*RG*)	0.005			-0.013			-0.029*		
	(0.034)			(0.028)			(0.015)		
log(*EIN*)	-0.068*			0.013**			-0.018		
	(0.043)			(0.005)			(0.052)		
log(*RL*)	-0.165			-0.124			-0.168***		
	(0.521)			(0.648)			(0.024)		
log(*PREG*)	0.293***			0.514***			0.240***		
	(0.093)			(0.167)			(0.037)		
log(*RC*)		0.175***			0.245***			0.237***	
		(0.046)			(0.089)			(0.064)	

(*Continued…*)

(Table 4 Continued)

Variable	Entire sample			High-income subsample			Low-income subsample		
	log(P)	log(y)	log(U)	log(P)	log(y)	log(U)	log(P)	log(y)	log(U)
log(RRD)		-0.008			0.045***			0.001	
		(0.029)			(0.005)			(0.096)	
log(UR)		0.373**	-0.363***		0.414	-0.323		0.113***	-0.370***
		(0.172)	(0.122)		(0.472)	(0.214)		(0.021)	(0.041)
log(RE)		0.238*			0.235**			0.215**	
		(0.130)			(0.108)			(0.104)	
log($INDS$)		0.024	-0.160		0.014	0.110		-0.020	-0.304***
		(0.017)	(0.511)		(0.038)	(0.806)		(0.064)	(0.114)
log($RFDI$)		0.155			0.091***			0.197**	
		(0.125)			(0.034)			(0.094)	
log(PUR)			0.186*			0.320***			0.273*
			(0.100)			(0.114)			(0.160)
Observations	130	130	130	44	44	44	86	86	86
adj. R^2	0.659	0.305	0.183	0.622	0.353	0.148	0.662	0.564	0.323

Note: the high- and low-income subsamples are sorted by following the 2010 classification scheme of the World Bank.

Table 3 presents robust evidence to support the contemporary RNHE model. Given that 11 countries have been excluded from the sample as shown in Table 3, we perform a further cross-sectional estimation for the system of simultaneous equations. Table 4 provides the cross-sectional estimation results in 2010, and these results remain robust.

Due to the heterogeneity of housing and services, it is difficult to obtain the directly comparable prices of housing and services between different countries. Therefore, the current empirical analysis uses the overall price level in the countries. However, the housing price gap between different countries is the key component of national price differences.

6. Conclusion

As a standard explanation for why housing and services are more expensive in rich countries than in poor ones, the BS model presupposes a homogeneous local labor force and intersectoral labor mobility. We propose a contrasting theory of the RNHE. Ours is a more general theory because it explicitly allows for local labor force heterogeneity and is formulated as a coherent supply-demand framework that incorporates demand-side factors such as the Linder effect. Our model also incorporates the BS model as a special case. To differentiate the RNHE model from the BS model, we develop a contemporary RNHE model that considers the prevalent outsourcing phenomenon. Since housing is not outsourceable, housing price is a key driving force of the price difference between rich and poor countries in the contemporary RNHE model.

This model predicts the differences between the national price level behaviors of high- and low-income countries. These predictions are empirically confirmed by estimating a system of simultaneous equations with panel data of 130 countries from 1990 to 2010. Specifically, for high-income countries, the unskilled proportion of the labor force has a significantly negative influence on the price level over and above its indirect effects through income, but such influence is not observed for low-income countries. The signs and significance of the coefficients do not considerably change across different settings, thereby indicating the robustness of our estimation results.

These results offer compelling evidence to support the superiority of the RNHE model over the BS model. The RNHE model provides a new concept for studying national price levels and the exchange rate formation processes. However, it is difficult to obtain directly comparable prices of housing and services between different countries. Future research may be fruitful to collect detailed data of comparable housing prices and examine their relative importance.

Acknowledgement

The authors thank Rose Lai (the editor) and an anonymous referee for their helpful comments. We gratefully acknowledge financial supports from the National Natural Science Foundation of China (71874195, 71871195, and 71988101), National Social Science of China (Major Project No. 19ZDA060), and a Humanities and Social Sciences grant from the Chinese Ministry of Education (18YJA790121).

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Appendix I Descriptive Statistics

Variable		Entire sample					High-income subsample					Low-income subsample				
		Mean	Std. Dev.	Min	Max	Observations	Mean	Std. Dev.	Min	Max	Observations	Mean	Std. Dev.	Min	Max	Observations
P	overall	0.648	0.312	0.123	1.834	N =650	1.016	0.273	0.568	1.834	N =170	0.507	0.186	0.123	1.421	N =480
	between		0.287	0.177	1.453	n =130		0.228	0.675	1.453	n =34		0.149	0.177	0.909	n=96
	within		0.125	0.156	1.160	T =5		0.155	0.673	1.398	T =5		0.112	0.015	1.019	T=5
y	overall	0.309	0.338	0.004	2.449	N =650	0.768	0.293	0.340	2.449	N =170	0.134	0.118	0.004	0.559	N =480
	between		0.328	0.006	1.577	n =130		0.252	0.411	1.577	n =34		0.115	0.006	0.529	n=96
	within		0.085	-0.626	1.187	T =5		0.154	-0.168	1.646	T =5		0.031	0.044	0.258	T=5
U	overall	1.268	0.097	0.944	1.443	N =650	1.181	0.082	0.944	1.394	N =170	1.301	0.081	1.022	1.443	N =480
	between		0.091	1.000	1.378	n =130		0.076	1.000	1.329	n =34		0.073	1.044	1.378	n=96
	within		0.035	1.126	1.370	T =5		0.033	1.039	1.267	T =5		0.036	1.223	1.403	T=5
POD	overall	1.039	0.245	0.090	1.533	N =650	0.849	0.186	0.361	1.348	N =170	1.112	0.225	0.090	1.533	N =480
	between		0.211	0.195	1.298	n =130		0.165	0.494	1.098	n =34		0.179	0.195	1.298	n=96
	within		0.125	0.763	1.339	T =5		0.090	0.572	1.107	T =5		0.137	0.849	1.412	T=5
RG	overall	0.913	0.332	0.600	3.030	N =650	1.357	0.299	0.909	3.030	N =170	0.743	0.118	0.600	1.231	N =480
	between		0.320	0.618	2.178	n =130		0.258	0.985	2.178	n =34		0.107	0.618	1.105	n=96
	within		0.092	0.038	1.764	T =5		0.156	0.481	2.208	T =5		0.050	0.613	0.876	T=5
EIN	overall	0.649	0.318	0.068	1.746	N =650	1.018	0.277	0.533	1.746	N =170	0.507	0.195	0.068	1.436	N =480
	between		0.290	0.140	1.476	n =130		0.229	0.676	1.476	n =34		0.154	0.140	0.861	n=96
	within		0.133	0.124	1.225	T =5		0.159	0.640	1.411	T =5		0.122	-0.018	1.083	T=5
RL	overall	0.937	0.249	0.023	1.487	N =650	0.749	0.200	0.210	1.289	N =170	1.009	0.228	0.023	1.487	N =480
	between		0.211	0.110	1.228	n =130		0.172	0.371	1.015	n =34		0.178	0.110	1.228	n=96
	within		0.134	0.605	1.267	T =5		0.105	0.467	1.024	T =5		0.143	0.677	1.339	T=5

(***Continued…***)

(Appendix I Continued)

Variable		Entire sample					High-income subsample					Low-income subsample				
		Mean	Std. Dev.	Min	Max	Observations	Mean	Std. Dev.	Min	Max	Observations	Mean	Std. Dev.	Min	Max	Observations
PREG	overall	1.215	0.332	0.900	3.242	N =650	1.648	0.317	1.000	3.242	N =170	1.050	0.122	0.900	1.471	N =480
	between		0.316	0.912	2.455	n =130		0.271	1.000	2.455	n =34		0.103	0.912	1.389	n=96
	within		0.104	0.368	2.001	T =5		0.169	0.800	2.434	T =5		0.065	0.831	1.244	T=5
RC	overall	0.648	0.324	0.005	1.715	N =650	1.018	0.281	0.456	1.715	N =170	0.506	0.205	0.005	1.467	N =480
	between		0.290	0.154	1.467	n =130		0.232	0.674	1.467	n =34		0.151	0.154	0.854	n=96
	within		0.145	0.128	1.290	T =5		0.162	0.662	1.438	T =5		0.139	-0.014	1.148	T=5
RRD	overall	0.840	0.250	0.052	1.432	N =650	0.662	0.211	0.130	1.190	N =170	0.908	0.230	0.052	1.432	N =480
	between		0.207	0.084	1.135	n =130		0.177	0.277	1.000	n =34		0.176	0.084	1.135	n=96
	within		0.141	0.483	1.205	T =5		0.118	0.326	0.981	T =5		0.149	0.550	1.273	T=5
UR	overall	0.822	0.332	0.500	2.749	N =650	1.162	0.300	0.741	1.649	N =170	0.654	0.127	0.500	1.161	N =480
	between		0.314	0.530	2.038	n =130		0.248	0.924	1.538	n =34		0.100	0.530	0.992	n=96
	within		0.113	-0.106	1.534	T =5		0.173	0.333	1.474	T =5		0.079	0.382	0.922	T=5
RE	overall	0.647	0.326	0.006	1.779	N =650	1.015	0.286	0.432	1.779	N =170	0.506	0.210	0.006	1.553	N =480
	between		0.289	0.193	1.512	n =130		0.233	0.680	1.512	n =34		0.151	0.193	0.864	n=96
	within		0.153	0.167	1.336	T =5		0.170	0.593	1.432	T =5		0.146	0.026	1.195	T=5
INDS	overall	0.551	0.246	0.002	1.207	N =650	0.388	0.224	0.002	1.000	N =170	0.614	0.224	0.004	1.207	N =480
	between		0.194	0.085	1.000	n =130		0.191	0.085	1.000	n =34		0.156	0.126	0.857	n=96
	within		0.152	0.165	1.005	T =5		0.121	0.002	0.719	T =5		0.162	0.227	1.067	T=5
RFDI	overall	0.529	0.332	0.200	2.501	N =650	0.965	0.301	0.441	2.501	N =170	0.363	0.132	0.200	0.939	N =480
	between		0.311	0.224	1.723	n =130		0.242	0.624	1.723	n =34		0.101	0.224	0.722	n=96
	within		0.120	-0.307	1.307	T =5		0.182	0.128	1.742	T =5		0.085	0.033	0.593	T=5
PUR	overall	1.928	0.984	0.056	5.231	N =650	1.124	0.647	0.056	2.870	N =170	2.981	0.935	1.000	5.231	N =480
	between		0.863	0.453	4.523	n =130		0.453	0.453	2.653	n =34		0.788	1.000	4.523	n=96
	within		0.478	0.385	4.144	T =5		0.463	-0.018	3.740	T =5		0.515	1.620	4.214	T=5

Note: the high- and low-income subsamples are sorted by following the 2000 classification scheme of the World Bank.

Appendix 2 Sorting of High-income and Low-income Subsamples

World Bank 2000

High-income Subsample	Australia, Austria, Barbados, Belgium, Brunei Darussalam, Canada, Hong Kong, Macao, Cyprus, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Kuwait, Luxembourg, Malta, the Netherlands, New Zealand, Norway, Portugal, Qatar, Singapore, Spain, Sweden, Switzerland, Taiwan, the United Arab Emirates, the United Kingdom and the United States of America.
Low-income Subsample	Afghanistan, Albania, Algeria, Argentina, Bahrain, Bangladesh, Belize, Benin, Bolivia, Botswana, Brazil, Bulgaria, Burundi, Cambodia, Cameroon, the Central African Republic, Chile, China, Colombia, Congo, Costa Rica, Côte d'Ivoire, Cuba, the Democratic Republic of the Congo, Dominican Rep., Ecuador, Egypt, El Salvador, Fiji, Gabon, Gambia, Ghana, Guatemala, Guyana, Haiti, Honduras, Hungary, India, Indonesia, Iran, Iraq, Jamaica, Jordan, Kenya, Lao People's Democratic Republic, Lesotho, Liberia, Libyan Arab Jamahiriya, Malawi, Malaysia, Maldives, Mali, Mauritania, Mauritius, Mexico, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Nicaragua, Niger, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, the Philippines, Poland, the Republic of Korea, Romania, Rwanda, Saudi Arabia, Senegal, Sierra Leone, South Africa, Sri Lanka, Sudan, Swaziland, the Syrian Arab Republic, Thailand, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkey, Uganda, the United Republic of Tanzania, Uruguay, Venezuela, Vietnam, Yemen, Zambia, and Zimbabwe

Excluding countries reclassified from low- to high-income countries

High-income Subsample	Australia, Austria, Belgium, Brunei Darussalam, Canada, Hong Kong, Cyprus, Denmark, Finland, France, Germany, Iceland, Ireland, Israel, Italy, Japan, Kuwait, Luxembourg, the Netherlands, New Zealand, Norway, Qatar, Singapore, Spain, Sweden, Switzerland, Taiwan, the United Arab Emirates, the United Kingdom and the United States of America.
Low-income Subsample	Afghanistan, Albania, Algeria, Argentina, Bangladesh, Belize, Benin, Bolivia, Botswana, Brazil, Bulgaria, Burundi, Cambodia, Cameroon, the Central African Republic, Chile, China, Colombia, Congo, Costa Rica, Côte d'Ivoire, Cuba, the Democratic Republic of the Congo, Dominican Rep., Ecuador, Egypt, El Salvador, Fiji, Gabon, Gambia, Ghana, Guatemala, Guyana, Haiti, Honduras, India, Indonesia, Iran, Iraq, Jamaica, Jordan, Kenya, Lao People's Democratic Republic, Lesotho, Liberia, Libyan Arab Jamahiriya, Malawi, Malaysia, Maldives, Mali, Mauritania, Mauritius, Mexico, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Nicaragua, Niger, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, the Philippines, Romania, Rwanda, Senegal, Sierra Leone, South Africa, Sri Lanka, Sudan, Swaziland, the Syrian Arab Republic, Thailand, Togo, Tonga, Tunisia, Turkey, Uganda, the United Republic of Tanzania, Uruguay, Venezuela, Vietnam, Yemen, Zambia, and Zimbabwe

(*Continued…*)

(Appendix II Continued)

World Bank 2010

High-income Subsample	Australia, Austria, Bahrain, Barbados, Belgium, Brunei Darussalam, Canada, Hong Kong, Macao, Cyprus, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Kuwait, Luxembourg, Malta, the Netherlands, New Zealand, Norway, Poland, Portugal, Qatar, the Republic of Korea, Saudi Arabia, Singapore, Spain, Sweden, Switzerland, Taiwan, Trinidad and Tobago, the United Arab Emirates, the United Kingdom and the United States of America.
Low-income Subsample	Afghanistan, Albania, Algeria, Argentina, Bangladesh, Belize, Benin, Bolivia, Botswana, Brazil, Bulgaria, Burundi, Cambodia, Cameroon, the Central African Republic, Chile, China, Colombia, Congo, Costa Rica, Côte d'Ivoire, Cuba, the Democratic Republic of the Congo, the Dominican Rep., Ecuador, Egypt, El Salvador, Fiji, Gabon, Gambia, Ghana, Guatemala, Guyana, Haiti, Honduras, India, Indonesia, Iran, Iraq, Jamaica, Jordan, Kenya, Lao People's Democratic Republic, Lesotho, Liberia, Libyan Arab Jamahiriya, Malawi, Malaysia, Maldives, Mali, Mauritania, Mauritius, Mexico, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Nicaragua, Niger, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, the Philippines, Romania, Rwanda, Senegal, Sierra Leone, South Africa, Sri Lanka, Sudan, Swaziland, the Syrian Arab Republic, Thailand, Togo, Tonga, Tunisia, Turkey, Uganda, the United Republic of Tanzania, Uruguay, Venezuela, Vietnam, Yemen, Zambia, and Zimbabwe