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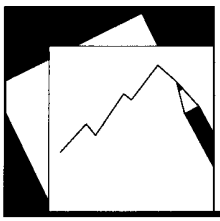

IMF Working Paper

Aggregate Investment Expenditures on Tradable and Nontradable Goods

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Aggregate Investment Expenditures on Tradable and Nontradable Goods

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Abstract

This paper shows that aggregate investment expenditure shares on tradable and nontradable goods are very similar across countries and regions. Furthermore, the two expenditure shares have remained close to constant over time, with the average expenditure share on nontradables varying between 0.54-0.62 over the 1960-2004 period. These empirical findings offer a new restriction for two-sector models of the aggregate economy. Combined with the fact that the relative price of nontradables correlates positively with income and exhibits large differences across space and time, our findings suggest that tradable and nontradable goods in investment can be modeled using the Cobb-Douglas aggregator.

JEL Classification Numbers: F41; E22

Keywords: Investment; tradable and nontradable goods; capital formation

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I. INTRODUCTION

Models with tradable and nontradable goods are widely used in macroeconomics. When writing down such a model, assumptions about parameter values and functional forms that capture the role of the two goods in consumption and investment are required. While the role of tradables and nontradables in consumption has been extensively researched in economic literature, a systematic examination of the investment side is missing.

This paper aims to fill this gap in the literature. It provides a systematic empirical examination of the role played by tradables and nontradables in aggregate investment. We find that on average around 60 percent of aggregate investment expenditures are spent on nontradables. Aggregate investment expenditure shares on tradable and nontradable goods show no correlation with income and are very similar in different regions of the world, such as Africa, South-East Asia, Europe or Latin America. Furthermore, the two expenditure shares have remained close to constant over time, with the average expenditure share on nontradables varying between 0.54-0.62 over the 1960-2004 period. At the same time, between some sample countries expenditure shares do exhibit sizable differences.

One of the most consistent related empirical findings in the macroeconomic literature is that the relative price of nontradable goods in terms of tradable goods exhibits a strong positive correlation with income in cross-section as well as time-series data.[2] As we show, price data for tradable and nontradable goods in investment offer no exception to this empirical regularity. Combined with the large variation in relative prices, our results suggest that at the level of aggregate economy investment process can be modeled using a unitary elasticity of substitution between tradable and nontradable goods, i.e., the Cobb-Douglas case, and a county-specific investment share parameter. We also show that if residential structures are excluded from investment data the weight of nontradables decreases to 46 percent of aggregate investment, but none of paper's other findings are significantly altered.

The results of this paper are applicable not only to small open economy models with tradable and nontradable goods, but also to closed economy models differentiating between equipment (or durable goods) and structures (or plants) in investment. This is the case since, as shown in the paper, 80-90 percent of the aggregate investment expenditures are spent on acquiring output from only two sectors of economic activity -- equipment from the manufacturing sector and structures from the construction sector. The former is a tradable good and the latter a nontradable good.

A frequent practice in the modeling literature has been to assume that only tradables or nontradables can be transformed into investment goods, or that the role of tradables and nontradables in investment is the same as in consumption.[3] Not surprisingly, our empirical results offer no support for such assumptions and, more importantly, allow to evaluate their appropriateness. There are also models in the literature that use detailed investment expenditure

[2] See, e.g., Balassa (1964), Samuelson (1964), Kravis et al. (1982) and De Gregorio et al. (1994).

[3] For examples of models with only tradables in investment see Rebelo and Vegh (1995), Obstfeld and Rogoff (1996), Mendoza and Uribe (2000), Uribe (2002). For a model with only nontradables in investment see van Wincoop (1993). For a model where the role of tradables and nontradables in investment is assumed to be the same as in consumption see Laxton and Pesenti (2003). For the later case we argue that it is, in fact, easier to determine the role of the two goods in investments than in consumption.

data to pin down country-specific investment expenditure shares and, out of functional appeal, have assumed that such expenditure shares remain constant.[4] For such models our paper provides supporting empirical evidence.

To our knowledge, no previous research has extensively examined the questions addressed in this paper. De Long and Summers (1991) and, more recently, Burstein et al. (2004) point out that investments have a very significant nontradable component. Drawing on evidence from 19 observations for medium and high income countries, Burstein et al. (2004) report a strong negative correlation (-0.69) between investment expenditure share on the output of construction sector and real per capita income. The considerably larger dataset of our paper does not support this finding. For the particular country-year observations, used by Burstein et al. (2004), our data also exhibit a negative correlation. However, when the whole dataset is considered, the correlation is close to zero.

We argue that empirical findings of this paper are compatible with other related findings in the literature, such as (i) no correlation between investment rates, measured in domestic prices, and income, (ii) positive correlation between equipment intensity in investment and income and (iii) less than unitary elasticity of substitution between tradables and nontradables in consumption. Paper also spells out restrictions for functional forms and parameter values that need to be imposed for a model to comply with our empirical findings. Distinction is made between models that assume an aggregate capital stock and models that differentiate between tradable and nontradable capital stocks.

The last section demonstrates that our findings can make a difference when models are used to explain data. Using a two-sector growth model, we investigate if low investment rates in poor countries, when measured in common international prices, can be explained with productivity differences between sectors producing tradables and nontradables. The model fares well, when standard assumptions in the literature are used, i.e., investment is mostly tradable and consumption nontradable. However, when we restrict the model's functional forms and parameters to comply with our empirical results, productivity differences can at best explain a small faction of variation in investment rates. This is the case, since, like consumption, investment expenditures are mostly nontradable.

The structure of the rest of the paper is as follows. Section 2 is devoted to documenting the structure of investment expenditures. We examine how much of the aggregate investment expenditures are spent on the output of different sectors of economic activity. This section also presents data sources and discusses several data related issues. Section 3 presents empirical findings about investment expenditures on nontradables in both time-series and cross-section data. In Section 4 we show that our findings fit in well with already established empirical regularities in the literature. Section 5 examines modeling implications of our findings and Section 6 provides an example of a modeling application where our empirical results matter. Finally, Section 7 concludes.

[4] See, e.g., Fernandez de Cordoba and Kehoe (2000) and Kehoe and Ruhl (2006) for open economy models and Greenwood et al. (1997) for a closed economy model.

II. STRUCTURE OF AGGREGATE INVESTMENT EXPENDITURES

This section first describes the importance of different sectors of economic activity in investment expenditures. Next, we divide the relevant sectors into sectors producing tradables and nontradables. Finally, we argue that investment expenditure data from national accounts can be used to examine the role of tradable and nontradable goods in investment.

A. Empirical evidence from input-output tables

What share of investment expenditures is spent on the output of different sectors of economic activity? We answer this question by looking at input-output table data for different countries and years between 1968 and 2001.

From late 60s until 1990 we focus on input-output table data compiled by the OECD. For details on data sources see Table 1**.** Summary of relevant data from this database is presented in Table 2**.** The expenditure pattern reveals that around 90 percent of all investment expenditures are spent on the output of only two sectors: manufacturing and construction. Furthermore, there are only two other sectors - retail/wholesale trade and real estate/business services - that account for any significant fraction of expenditures. Together these four sectors account for 98 percent of aggregate investment expenditures.[5] The described pattern of expenditures shows little systematic variation over the period of coverage.

The decade of 90s comes with a break in data, as countries gradually started implementing the SNA93 definitions for compiling national accounts. For the purpose of this study the switch from SNA68 to SNA93 can potentially have important consequences, since expenditures on computer related services, e.g. software, are moved from intermediate consumption into investments. SNA93 is also more explicit about other investment expenditures on services, which need to be separated from expenditures on the output of manufacturing and construction sectors.

Since many countries are still in the process of implementing SNA93 definitions, our main focus for the post-1990 period is on the 1997 benchmark input-output table for the U.S., which is the most comprehensive effort to date.[6] Findings for the U.S. are then compared with available input-output table data for other economies.

Table 3 summarizes the pattern of investment expenditures for the U.S. in 1997 and can be compared with data for the U.S. in Table 2. The same four sectors comprise 97.4 percent of aggregate investment expenditures. After introducing investment expenditures on 'software' and 'computer system design and related services', real estate/business services sector accounts for 12.1 percent of investment expenditures, with a corresponding decrease in the weights of manufacturing and construction sectors. The rest of the expenditure structure is in line with the results for 1968-1990 period. Input-output table data for other countries, presented in Table 4**,** broadly agree with the findings for the U.S. economy.

Overall, aggregate investment expenditure data from input-output tables draw a consistent

[5] Aggregate investment expenditures include expenditures on both domestic and imported goods/services.
[6] See Lawson et al. (2002) for details and further data sources.

picture: (i) expenditures on the output of manufacturing and construction sectors are dominant, with their weight gradually decreasing from 0.9 in 70s to 0.8 by year 2000; (ii) this decrease is countered by the gradual emergence of 'software' and especially 'computer system design and related services' as non-negligible components of investment expenditures;[7] (iii) retail/wholesale trade services account for 5-7 percent of investment expenditures throughout the 1968-2001 period; (iv) the four sectors together account for around 98 percent of aggregate investment expenditures.

B. Implications for tradables and nontradables

Next, we need to map the observed investment expenditure pattern into expenditures on tradables and nontradables. This is done in two steps. First, as a common practice in the literature, we assume that the output of the distribution sector, i.e. retail/wholesale trade, is nontradable. Second, the nature of the output of the other three relevant sectors is defined according to their tradability relative to the retail/wholesale trade sector. Tradability is measured as the sum of a sector's exports and imports over the gross output.[8]
Results for 27 countries with an input-output table available during the 1995-2001 period are presented in Table 5. Tradability of construction sector's output is uniformly lower than tradability of the retail/wholesale trade sector's output. Consequently, output of construction sector is defined as a nontradable good. Manufacturing sector exhibits uniformly higher tradability than the retail/wholesale trade sector, therefore its output is defined as a tradable good.

Tradability of the real estate/business services sector is broadly similar to tradability of the distribution sector. For majority of countries, including the U.S., it is lower than tradability of the distribution sector. However, the sample also includes several relatively small and open economies with a significantly higher tradability in the real estate/business services sector, e.g. Finland. To classify this sector we examine separately four of its subsectors in the U.S. benchmark input-output table for 1997: (i) real estate services, (ii) computer system design and related services, (iii) software and (iv) other business services. Applying our definition of tradability to this more disaggregated data suggests that the two largest subsectors - 'real estate services' and 'computer system design and related services' - should be defined as nontradables, while output of the remaining two sectors - 'software' and 'other business services' - should be defined as tradable.[9] Since for the U.S. economy the two tradable subsectors account for 31 percent of total investment expenditures on the sector's output (see Table 3), we define the sector as 2/3 nontradable and 1/3 tradable.[10]

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[7] For a more detailed discussion of investment expenditure pattern on software and related services in the USA during 1960-2000 period see Parker and Grimm (2000).
[8] For examples of earlier application of the same measure of tradability see De Grigorio et al. (1994) and Betts and Kehoe (2001).
[9] For two subsectors - 'real estate services' and 'other business services' - these findings are confirmed by input-output table data for other countries. Unfortunately, no subsectors comparable to 'computer system design and related services' or 'software' are available for other countries.
[10] An alternative approach also considered in this study is to define output of the real estate/business services sector as nontradable. Out of the two approaches we present results for the one that is less favorable to the main findings of this paper - close to constant aggregate investment expenditure shares across income and time. Note also that, since nontradable construction and tradable manufacturing sectors dominate investment expenditures, the effect of the particular assumption about the tradable-nontradable nature of the remaining sectors is very limited.

What conclusions can we draw about the role of tradables and nontradables in investments from the input-output table data? After applying our definitions, results from input-output table data are summarized in Table 6**.** Depending on the period, 59-64 percent of aggregate investment expenditures are spent on nontradable goods.

C. Alternative data sources

While input-output table data on investment expenditures is sufficient to draw general conclusions about the relative importance of tradables and nontradables in aggregate investments, the coverage of the data is too limited to say anything definitive about the questions we set out to answer in this paper -- the behavior of the two investment expenditure shares over time and across income levels. However, the finding that manufacturing and construction dominate investment expenditures allows us to use detailed gross fixed capital formation (GFCF) data from 'GDP by expenditure' approach in national accounts to find answers to the remaining questions.

'GDP by expenditure' data divides investment spending into expenditures on residential structures, nonresidential structures and equipment/machinery, thus allowing the separation of expenditures between nontradable output of the construction sector and tradable output of the manufacturing sector. Under the SNA93 definitions, GFCF data also accounts separately for the output of the real estate/business services sector.

The only notable problem with such data is that it measures expenditures at purchaser's prices and therefore do not account separately for expenditures on the retail/wholesale trade sector. Most of the expenditures on the output of this sector are accounted for together with expenditures on equipment/machinery. GFCF data from national accounts should therefore overestimate the weight of the expenditures on tradables by 0.01-0.10, which is the range of investment expenditure shares on the nontradable output of the retail/wholesale trade sector (see Tables 2-4). Appendix I compares investment data from input-output tables and national accounts. In line with the expected bias, we find that national accounts data overestimate the share of tradables in investment by up to 0.09.

Besides the bias, national accounts data also offers several advantages. First, it has a much wider coverage, with yearly data starting from 1950 and cross-sections of up to 115 countries. Second, national accounts data offers a better comparability across time and space than input-output table data. In the rest of the paper we therefore build on the time-series and cross-section evidence from GFCF data of national accounts.

Several *distinct* datasets are used. We look at annual GFCF data from the United Nations (UN) detailed national accounts statistics (see UN (2001a, b)). This data is compiled using SNA68 definitions and is the only one to cover the period between 1950 and 1970. Due to the switch to SNA93 definitions, this dataset was discontinued in 1997. Also examined are annual GFCF data from OECD detailed national accounts statistics, compiled using SNA93 definitions (see OECD (2006)). This dataset is the only one to cover the period from 1997 onwards. Finally, we consider investment expenditure data from Penn World Table (PWT) benchmarks (see Summers et al. (1995) and Heston et al. (2002)). PWT benchmark data are further complemented with data from Nehru and Dhareshwar (1993). This dataset is not at an annual frequency, but offers the largest cross-section sample with 115 countries. Further details on the three datasets are provided in Table 1.

III. INVESTMENT EXPENDITURES ON NONTRADABLES IN NATIONAL ACCOUNTS

A. Time-series data

We start by depicting annual time-series data for the six largest OECD economies in Figure 1**.** In line with the evidence from input-output table data, investment expenditures on nontradable goods for any given year are in 0.47-0.68 range. Furthermore, with a possible exception of France, expenditure shares show no systematic trend over the period for which data is available. It should also be noted that there are persistent differences in expenditure shares between some of the countries, e.g. France and UK. These six largest OECD economies are representative of the rest of the sample countries.

To formalize the above observations**,** Tables 7 and 8 present relevant summary statistics for the sample of OECD and UN data. Staring with Table 7, all country-year observations of the nontradable investment expenditure share are between 0.35-0.77, with the sample average of 0.59. As in Figure 1, there are notable differences in investment expenditures on nontradable goods between some of the countries. For example, the highest average expenditure share on nontradable goods (Iceland, 0.67) is by 0.25 higher than the lowest average expenditure share (Slovak Republic, 0.42). The pattern of high and low expenditure shares is persistent over time. To measure this persistence, we divide the OECD dataset into three equal eleven-year periods and calculate the correlation of nontradable expenditure shares between any two periods. Between 1970-80 and 1981-91, the expenditure share correlation is 0.63. For 1970-80 and 1992-2002, the correlation is 0.46. Between 1981-91 and 1992-2002, the correlation is 0.81.

The last two columns in Table 7 report point estimates of a simple linear time trend and standard errors for countries with at least 30 annual observations. Note that these time trends are expressed as a change in aggregate investment expenditure shares on nontradables over a *decade*. For eight countries out of thirteen, the time trend is not significantly different from zero at the 5 percent confidence level. Furthermore, with the exception of Denmark, the point estimates of the time trends are between -0.024 to 0.027 per decade.

Data from the UN national accounts, summarized in Table 8, provide further support for the observations made with the OECD data. The UN dataset includes at least one observation for 113 countries and exhibits considerable cross-country variation in expenditure shares, with the averages ranging from 0.34 for Saint Kitts and Nevis to 0.97 for Kyrgyzstan. Table 9 reports the persistence of cross-country differences in expenditures on nontradables in the UN dataset, divided into five periods: 1950-59, 1960-69, 1970-79, 1980-89 and 1990-97. Correlations of the expenditure shares between any subsequent decades are in the 0.64-0.86 range, with a smaller, but still positive, correlation between any other decades.

The last two columns in Table 8 present results from time trend regressions in the UN data for countries with at least 30 annual observations. In general, time trend estimates are similar to what was already reported in Table 7, although for several low income countries, e.g. Lesotho and Guatemala, point estimates of the time trends are considerably larger than for the OECD countries.

To further examine trend differences between OECD and non-OECD countries, Panel 1 in Table 10 shows results for a pooled regression and a panel regression with country dummies from the OECD national accounts data. In both cases results show a small and negative trend, which is negligible in economic terms and not significantly different from zero at the 5 percent confidence level. Panel 2 in Table 10 shows results from the UN dataset. In this case time trends are somewhat larger and statistically significant at the 5 percent confidence level. Depending on the sample and regression specification point estimates of the time trend vary between -0.020 to -0.012 per decade. As can be expected, time trends in non-OECD countries have higher standard errors. Nevertheless, the point estimate of the time trend for non-OECD countries is similar to what we observe for OECD countries, ranging from -0.020 to -0.016 per decade.

Finally, Figure 2 depicts the sample average expenditure shares on nontradables in the OECD and UN data for each of the years. Given the findings for individual countries, it is not surprising that the two datasets exhibit no economically significant time trends. Furthermore, the average expenditure shares are very similar in the two datasets, indirectly indicating that OECD and non-OECD countries spend a similar share of investment resources on nontradable goods. Next, we turn to examining this last observation in more detail.

B. Cross-section data

Does the share of investment expenditures on nontradables vary systematically across different country characteristics, most importantly the level of income? Table 11 presents cross-section results from the UN dataset for each year between 1950 and 1997. The mean of the sample, also depicted in Figure 2, was already discussed with the time-series evidence. The fourth column of Table 11 shows the correlation between the expenditure share and PPP adjusted income per capita.[11] In all but a few sample years the correlation is within 0.00-0.30 range, with zero correlation rejected at 5% confidence level for four out of 48 sample years. The average correlation during 1950-97 is 0.10. The last two columns of the table show trend coefficients and robust standard errors from a regression of nontradable investment share on log real per capita income. For all but five years a zero trend cannot be rejected at 5% confidence level. Overall, in the UN dataset, we find a small and positive correlation between expenditure shares and per capita income, which is not significantly different from zero.

To illustrate the correlation between income and expenditure shares, Figure 3 plots the two data series for years 1960, 1970, 1980 and 1990, with 1970 and 1990 representing the five sample years when zero trend and correlation are rejected. A linear trend fitted into subplots of Figure 3 suggests that a country with a per capita income of 10 percent of the average OECD level exhibits an expenditure share on nontradables, which is 0.01-0.05 lower than in the OECD countries. In line with the time-series evidence, between some countries there are large differences in expenditure shares.

Cross-section results from the PWT benchmark data, presented in Table 12, reveal a similar picture. For all six sample years, the correlation is positive and in five cases out of six, the correlation is between 0.04 and 0.31.

[11] Other measures of income - GDP per capita in current prices and real GDP per worker in constant international prices - produced almost identical correlation patterns.

Next, we investigate if there are systematic differences in investment expenditure shares across different regions of the world. Figure 4 plots the UN data separately for four country groups: Africa, Europe, Latin America and South East Asia.[12] Regional investment shares are calculated as simple arithmetic averages. In line with the observed small and positive correlation between income and expenditure share on nontradables, average expenditure share for European countries is higher than, for example, in Africa. Nevertheless, the expenditure shares in the four regions do not deviate from the sample mean by more than 0.05.[13]

The size of largest PWT benchmark dataset for 1996 allows for a more detailed look at the regional differences. Table 13 shows investment expenditure shares on nontradables when all sample countries are grouped into seven regions. Once again, there is very little variation. The coefficients for the seven country groups range between 0.51 and 0.59. The only notable exception in the PWT 1996 benchmark dataset is Africa, where the share is considerably lower than in the other regions.[14] Due to this exception, Table 13 also includes average coefficients for Africa in 1985 and 1980 PWT benchmark datasets, both of which show no deviation from sample averages.

Results for various regions are not affected, if country observations are weighted by total GDP in international prices. The average correlation between the total GDP in international prices and the expenditure shares in the UN dataset is 0.07, with correlations for different years varying in the -0.10 to 0.15 range.

Finally, we investigate how the exclusion of residential structures from investment data would affect the results of this paper. With few exceptions both OECD and UN national accounts data distinguish between investment expenditures on residential and all other structures. Dashed lines in Figure 2 show the average investment expenditures on nontradables in UN and OECD data, when expenditures on residential structures are excluded from investment.[15] When compared with data that include residential construction, the only notable difference is the uniformly lower expenditure share on nontradables, decreasing from an average of 0.60 to 0.47 in OECD data and 0.58 to 0.45 in UN data. None of the other findings of this section are significantly altered. Results show that expenditures on residential structures account for a quarter of all investment expenditures and do not vary systematically with the level of income. For the 1960-1996 period correlation coefficients are in -0.25 to 0.07 range with an average correlation of -0.09.

Implications for modeling from the above documented empirical regularities depend crucially on the behavior of underlying prices for the two investment components. Relative price behavior of tradable and nontradable goods has been extensively documented in the literature, which finds a strong and positive correlation between income and the relative price of nontradable goods.[16]

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[12] Years before 1960 are excluded from the figure, since the number of countries did not exceed two in any of the groups. For the same reason we have also excluded observations for 1997 and in case of Africa also 1996.
[13] The two exceptions to this rule are Latin America in the 1960s and Africa during 1986-87 and 1990-94.
[14] In 1996, investment expenditure share on nontradables in each of sample's 22 African countries is below the sample average of 0.51. Since Africa represents a sizable country group, this explains why the average coefficient in the whole PWT 1996 benchmark dataset (see Table 12) is lower than in previous years.
[15] Due to the lack of detailed data, years before 1960 were excluded from the UN sample.
[16] See, e.g., Balassa (1964), Samuelson (1964), Kravis et al. (1982) and De Gregorio et al. (1994).

Tradables and nontradables in investment present no exception to these findings. As shown in Figure 5, in poorest developing countries relative price of nontradables in investment is a third of the same price in advance economies. Similarly, the relative price of nontradables in investment has on average doubled in the largest OECD economies over the last 30 years (see Figure 6). In the U.S. it has more than tripled over the same period.

To sum up the empirical results of this section, we have documented that investment expenditure share on nontradables has been close to constant over the last 50 years and exhibits no significant correlation with the level of income. This is the case despite the fact that the relative price of the two investment components varies systematically and substantially with the level of income as well as over time.

IV. COMPATIBILITY WITH RELATED EMPIRICAL REGULARITIES IN THE LITERATURE

Our findings fit in well with the body of already established empirical regularities relating structure of the economy to the level of income. This provides an additional reliability check for our results.[17] To provide some structure to the discussion, consider a two sector economy with the following aggregate resource constraint

$$c_T^z + p_N^z c_N^z + i_T^z + p_N^z i_N^z = p_N^z y_N^z + y_T^z = 1, \tag{1}$$

where subscripts T and N denote tradables and nontradables and superscript z denotes income level. c_j^z is consumption of good j, i_j^z is investment of good j and y_j^z is output of good j, $j = \{T, N\}$, at income level z. Constraint is formulated in terms of tradables, so that p_N^z is the relative price of nontradables. All values are expressed as a share of aggregate output.

In terms of (1), our empirical findings can be summarized as

$$\frac{i_T^z}{i_T^z + p_N^z i_N^z} = \gamma. \tag{2}$$

Regardless of the level of income, a constant fraction, γ, of investment expenditures is spent on tradables, with the remaining expenditures, $1-\gamma$, spent on nontradables.

Eaton and Kortum (2001) note that investment expenditures on equipment/machinery, as a share of GDP, do not vary systematically with the level of income. In terms of (1), denote this result as

$$i_T^z = \tau, \tag{3}$$

Combining (2) and (3), aggregate investment rate, as a share of output, can be expressed as

$$i_T^z + p_N^z i_N^z = \frac{\tau}{\gamma}. \tag{4}$$

An implication of empirical findings in (2) and (3) is that the aggregate investment rate, as a share of output, should also be constant. Parente and Prescott (2000), Restuccia and Urrutia (2001) and Hsieh and Klenow (2007), among others, find that this indeed is the case for a wide set of

[17] In some of the discussion in this and the following sections we implicitly equate tradables with equipment/machinery and nontradables with structures. As was discussed in Section 2, such equalization finds empirical support.

countries over the 1960-2000 period.

The connection between above regularities can be exploited further to indirectly establish a link between the role of tradables and nontradables in output and consumption. In particular, there is an agreement in the literature that the share of nontradables in output increases with the level of income (see Kravis et al., 1982). Then, according to (1)-(3), the same should be the case for consumption. To see this, we rewrite (1) in terms of sectoral resource constraints and substitute in constant terms from (3) and (4) to obtain

$$\begin{aligned} c_T^z &= y_T^z - \tau, \\ p_N^z c_N^z &= p_N^z y_N^z - \tau \frac{1-\gamma}{\gamma}. \end{aligned} \tag{5}$$

With constant investment shares in both sectors, changes in sectoral expenditure shares for output and consumption must have the same sign.[18]

When combined with an increasing relative price for nontradables, this result is useful for models that restrict aggregation of sectoral consumption to the CES function. In this case, a simultaneous increase in the relative price and expenditure share for a consumption component implies that the elasticity of substitution must be less than unitary. This is indeed what several earlier papers that directly estimate the elasticity of substitution between tradables and nontradables in consumption in the CES framework have found.[19] The indirect evidence of our paper is reassuring, given the difficulties with distinguishing between tradable and nontradable goods in aggregate consumption data (see e.g. Burstein et al. (2005)).

Next, consider once again the empirical regularity that the relative price of nontradables increases with the level of income. Combined with findings in (2)-(4), this implies that, as per capita income increases, investment become more intensive in tradable goods or equipment. More formally, in terms of a given relative international price p_N^{PPP}, we have

$$\frac{\partial\left(\frac{i_T^z}{i_T^z + p_N^{PPP} i_N^z}\right)}{\partial z} = \frac{\partial\left(\frac{\tau}{\tau + p_N^{PPP} i_N^z}\right)}{\partial z} > 0, \tag{6}$$

since $\frac{\partial p_N^z}{\partial z} > 0$ and from (2) and (3) $\frac{\partial\left(p_N^z i_N^z\right)}{\partial z} = 0$. This implication of our findings is in line with Summers and De Long (1991, 1993), who in a series of papers find a strong positive correlation between equipment intensity of investment and economic growth.

Finally, our cross-section results differ from findings in Burstein et al. (2004), who in a sample of 19 country-year observations from input-output tables find a negative correlation between the investment expenditure share on the output of construction sector and real per capita income. To reconcile the findings of the two studies, Table 14 presents the results of Burstein et al. (2004) and replicates their study using national accounts data.

Columns 1-4 of the table present the results of Burstein et al. (2004), where authors find that

[18] For this result to hold, we have assumed that net trade does not vary systematically with the level of income or that any such variation, as a share of output, is negligible.

[19] See, e.g., Kravis et al. (1982), Mendoza (1995), Stockman and Tesar (1995).

investment expenditure share on construction and per capita income have a correlation coefficient of -0.69. Notice that data for each country refer to some year over the 1990-1999 period, presented in the second column. The last column of the table presents the corresponding country-year data from our paper.

What explains the large differences in correlation between real income per capita and investment expenditure shares in our paper and Burstein et al. (2004)? The correlation coefficient for the same country-year observations in our sample is -0.49. Thus, bulk of the difference can be explained with the particular 19 country-year observations on which Burstein et al. (2004) results are based. For 9 out of 19 sample countries data are for the 1995-96 period. Cross-section results in Table 11 show that for these two particular years, the UN data also exhibit negative correlations between per capita income and expenditure shares (-0.15 in 1995 and -0.23 in 1996). However, these two years are outliers when compared to the whole sample.

V. IMPLICATIONS FOR MODELING CHOICES

This section examines implications of our findings for various specifications of two-sector models that differentiate between tradable and nontradable goods in investment. To simplify the exposition we abstract from modeling the household sector and focus on production functions and resource constraints. The goal is to identify restrictions on functional forms and parameter values that ensure models' compliance with constant investment expenditure shares on tradables and nontradables.

A. Models with aggregate capital stock

To start, consider a model economy with two sectors, as already presented in the previous section: one produces tradables, including machinery/equipment and the other produces nontradables, including structures. We have

$$\begin{aligned} c_N + i_N &= F_N(k_N, l_N), \\ c_T + i_T &= F_T(k_T, l_T), \end{aligned} \tag{7}$$

where, in addition to already introduced notation, output in sector j, $j = \{T, N\}$, is produced using aggregate capital, k_j, and labor, l_j. Capital is accumulated according to

$$k_N' + k_T' = (1-\delta)(k_N + k_T) + F_I(i_T, i_N), \tag{8}$$

where prime refers to next period variables and δ denotes depreciation rate and augmenting of capital requires both tradable and nontradable goods as investment inputs. This is a commonly used specification in the literature.[20]

For this specification of the two-sector model to generate constant investment expenditure shares we need to impose a Cobb-Douglas aggregation for the two investment goods,

$$F_I(i_T, i_N) = \frac{1}{(1-\gamma)^{1-\gamma}\gamma^{\gamma}} i_T^{\gamma} i_N^{1-\gamma}, \tag{9}$$

[20] See, e.g., Brock and Turnovsky (1994) and Fernandez de Cordoba and Kehoe (2000) for models that comply with this model specification.

where, borrowing notation from (2), investment expenditure shares on tradables and nontradables are denoted correspondingly with γ and $1-\gamma$. This specification will comply with our empirical findings regardless of the elasticity of substitution between aggregate production factors. Also, factor intensities in production are allowed to differ across sectors.

This simple model abstracts from some of the features that are commonly included in two-sector models with aggregate capital stock. For example, we have eliminated trade flow considerations by assuming that domestic and foreign tradable goods are perfect substitutes. Attention is restricted to the case of balanced trade. Distribution sector is not modeled explicitly and included in the nontradables. Generalizing the model in these dimensions would not invalidate the modeling implications of our empirical findings, since all of these more elaborate versions of the two sector model still require an assumption about the role of tradables and nontradables in investment.

B. Models with tradable and nontradable capital

There are a number of macroeconomic problems were we do not want to aggregate investment into an aggregate investment good and aggregate capital stock, since equipment and structures can augment capital differently and can play a different role in production. One commonly modeled difference is to allow tradable and nontradable capital stocks to have different depreciation rates. Consider a specification of the two-sector model, as studied by Greenwood et al. (1997), with

$$F_j(.) = F_j\left(\kappa(k_{jT}, k_{jN}), l_j\right), \tag{10}$$

where k_{ji} is capital stock of type i, $i = \{T, N\}$, located in sector j, $j = \{T, N\}$. Capital of type i is accumulated according to

$$k_{Ti}^{'} + k_{Ni}^{'} = (1-\delta_i)(k_{Ti} + k_{Ni}) + i_i, \tag{11}$$

where depreciation rate, δ_i, is now allowed to differ by type of capital. Note that $\kappa(.)$ in (10) is the same in both sectors, so that the two types of capital play the same role in production of tradables and nontradables.

For this model specification to comply with our empirical findings, (10) needs to be restricted to

$$\kappa(.) = k_{jT}^{\theta} k_{jN}^{1-\theta}, \tag{12}$$

where

$$\theta = \frac{\gamma\delta_N(r+\delta_T)}{\gamma\delta_N(r+\delta_T) + (1-\gamma)\delta_T(r+\delta_N)}, \tag{13}$$

with r denoting net return on capital. Equation in (13) relates the relative size of capital income shares, θ, to the relative size of investment expenditure shares, γ.

In this case restrictions on functional forms and parameter values are only slightly altered from the case of an aggregate capital stock. To see this, note that if $\delta_T = \delta_N$, then $\theta = \gamma$ and the two models are the same. If $\delta_T \neq \delta_N$, the only alteration is the adjustment in (13) for different depreciation rates for two types of capital. As a result, if, e.g., $\delta_T > \delta_N$, income share for tradable capital is bigger than investment expenditure share on tradables, $\theta > \gamma$.

Our suggested restriction on the functional form of the production function is nothing new to the

modeling literature. On the contrary, Greenwood et al. (1997) and several other papers assume the exact functional form in (12). Similarly, for models with aggregate capital stock, Fernandez de Cordoba and Kehoe (2000) use the functional form in (9). However, beyond the obvious functional appeal, no systematic empirical evidence motivating the choice has been presented in previous literature.

C. Models with capital-skill complementarity

Our empirical findings can also be applied to models that study capital-skill complementarity. In this case, (10) is generalized to

$$F_j(.) = F_j(k_{jT}, k_{jN}, l_{jS}, l_{jU}), \tag{14}$$

where l_{jm} stands for skilled, $m = S$, or unskilled, $m = U$, labor located in sector j, $j = \{T, N\}$. If the model assumes that skilled and/or unskilled labor is a complement/substitute with the aggregated capital stock, as in e.g. Caselli and Coleman (2006), then (14) can be recast as (10) and our earlier results apply.

Some recent modeling efforts have instead assumed that only tradable capital stock and skilled labor exhibit a complementarity. Consider, for example, the following double-nested CES functional form used in Krusell et al. (2000)

$$F(k_{jT}, k_{jN}, l_{jS}, l_{jU}) = k_{jN}^{\theta}\left[(1-\mu)\left[\lambda k_{jT}^{\rho} + (1-\lambda) l_{jS}^{\rho}\right]^{\frac{\sigma}{\rho}} + \mu l_{jU}^{\sigma}\right]^{\frac{1-\theta}{\sigma}}, \tag{15}$$

where Cobb-Douglas aggregation between nontradable capital, k_{jN}, and other production factors is imposed, with θ capturing the income share of nontradable capital; ρ is elasticity of substitution between tradable capital and skilled labor; σ is elasticity of substitution between skilled and unskilled labor, as well as between tradable capital and unskilled labor. μ and λ determine weights for tradable capital, skilled labor and unskilled labor in production.

Taking as given the trend in the relative price of nontradables, production function in (15) is not compatible with empirical results of this paper, unless $\rho = 0$ and $\sigma = 0$. As discussed in, e.g., Hornstein and Krusell (2003), if there is a trend in the relative price, CES production function with non-unitary elasticity of substitution will lead to a trend in expenditure shares and some production factor is eventually not used in production. The same reasoning applies to capital income shares in (15).

VI. AN APPLICATION TO THE GROWTH LITERATURE

In this section we apply our empirical findings and its modeling implications to the literature that investigates the relationship between sectoral productivity levels and income disparity across countries.[21] We further narrow down the focus to the link between sectoral productivities and differences in investment rates across countries.[22] Relevant empirical regularities were already

[21] For recent contributions see e.g. Herrendorf and Valentinyi (2006) and Hsieh and Klenow (2007).
[22] Mankiw et al. (1992) find that differences in investment rates account for around half of the income disparity across countries.

noted in Section 4. When measured in international prices, investment rates in low income countries are a fraction of investment rates in rich countries, while in domestic prices investment rates show no economically significant correlation with income. One possible interpretation of these empirical regularities is to link them to differences in sectoral productivities and relative prices between tradables and nontradables across countries (see Balassa (1964) and Samuelson (1964)).

A. Two-sector model

We explore this link using a two-sector growth model with tradable and nontradables goods, where countries differ only in terms of their relative sectoral productivities, and show that results depend crucially on the assumed role for the two types of goods in investment. If investment goods are tradable and consumption nontradable, the link provides a potent channel for explaining the observed differences in investment rates. If, however, the role of tradables and nontradables is based on our empirical findings, productivity and relative price differences can account for no more than a small fraction of differences in investment rates across countries.

To see this, consider the model partly sketched out in previous sections. Representative consumer maximizes utility,

$$u\left(F_C\left(c_T, c_N\right)\right), \tag{16}$$

subject to sectoral resource constraints in (7) and a steady state version of capital accumulation in (8). Aggregate labor supply is inelastic and foreign trade position is assumed to be balanced. Model economy takes world the interest rate, r, as given.

To solve the model we assume that investments are aggregated using the empirically motivated functional form in (9). For consumption, motivated by the discussion in Section 4, we assume CES aggregator,

$$F_C(c_T, c_N) = \left(\mu c_T^{\frac{\theta-1}{\theta}} + (1-\mu) c_N^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}}, \tag{17}$$

and, in line with the literature, production functions for the two types of goods are assumed to be of Cobb-Douglas form,

$$A_j k_j^{\alpha} l_j^{1-\alpha}, \tag{18}$$

with A_j representing total factor productivity in sector j, $j = \{T, N\}$.

Model's analytical solution is presented in Appendix II. Before turning to a quantitative investigation, two results are worth pointing out. First, domestic price investment rate in the model is

$$\frac{i_T + p_N i_N}{i_T + c_T + p_N\left(c_N + i_N\right)} = \frac{\alpha\delta}{r+\delta}. \tag{19}$$

It does not depend on productivities and is therefore the same for all model economies. This result finds support in data.

Second, relative price of nontradables is determined by the ratio of sectoral productivities, $p_N = \frac{A_T}{A_N}$. This Balassa-Samuelson effect is crucial for understanding the link between relative productivities and investment rates in common international prices. In the model, lower income level is a result of lower relative productivity in the tradable sector and is accompanied with a

lower relative price of nontradables. Domestic price investment rates do not vary with income, but when expressed in international prices investment rates will vary because of differences in the relative price, p_N. The sign of the variation depends on the role that tradables and nontradables play in investment, relative to in the rest of the economy, i.e. consumption. If expenditure share on tradables is the same in consumption and investment, relative price movements will affect consumption and investment equally and therefore will not affect investment-output or consumption-output ratios. If investment expenditure share on tradables in investment is larger than in consumption, lower relative price will result in lower investments rates, when expressed in common international prices.[23] Through this channel the model can potentially explain the observed differences in investment rates. The remainder of this section investigates if this channel is quantitatively relevant.

B. Quantitative results

As already noted, the nature of the exercise is to compare solutions for model economies that differ in terms of relative productivities in tradable and nontradable sectors. In all other respects model economies are identical. We then investigate quantitatively the variation in investment rates that differences in relative productivities can generate.

Model is calibrated to a representative high income economy, defined as the average of countries with at least 75 percent of the U.S. income level. Calibration amounts to setting investment rate in (19) and three parameters that determine the role of tradables and nontradables in consumption and investment, θ, μ and γ. We set investment rate to 0.23, which is the average for the relevant set of countries, and consider several specifications for the remaining parameters.[24]

First we solve the model for the case of tradable investment and nontradable consumption, which amounts to setting $\mu = 0$ and $\gamma = 1$. Although in violation of empirical evidence, this parametrization allows the model to generate maximum variation in investment rates. Results are summarized with the doted line in Figure 7. In this figure, the x-axis represents income disparities across countries, exogenously generated in the model by varying the relative productivity. Values are normalized by the high income country. The y-axis represents the international price investment rate, expressed in terms of the relative price in the high income country. For comparative purpose, Figure 7 also depicts the actual international price investment rates from 1996 benchmark data and a simple linear trend. Clearly, the magnitude of differences in international price investment rates observed in data can be generated with the model, since with $\mu = 0$ and $\gamma = 1$ variation in the model exceeds variation in data.

Next, consider an empirically motivated parametrization. For investment shares we set $\gamma = 0.4$. For elasticity of substitution in consumption we set $\theta = 0.44 < 1$, as reported in Stockman and Tesar (1995) and indirectly supported by results of this paper. Weight parameter μ is set so that in the high income country consumption expenditure share on tradables is 0.25, as reported in

[23] For a formal derivation of this result see Appendix B.

[24] Note that for high income country the two investment rates coincide. Also, model parameters for the aggregate economy, i.e. δ, α and r, affect the results only through their effect on the domestic price investment rate and therefore do not need to be calibrated separately.

Burstein et al. (2004).[25] With this model specification, as relative productivity decreases below the level of high income countries, investment rates initially decrease slightly, since expenditure share on tradables is higher in investment, i.e., 0.44, than in consumption, i.e., 0.25. However, with less than unitary elasticity of substitution, expenditure share on tradables in consumption increases as income levels decrease. Eventually, with low enough income, it exceeds that of investment, causing investment rates to increase. Thus, under this empirically motivated parametrization, the model cannot explain why investment rates decrease with income.

Finally, given the uncertainties surrounding parametrization of the consumption side, Figure 7 also reports the solution for model parametrization with $\gamma = 0.4$ and only nontradables in consumption, i.e. $\mu = 0$. In this case, the model can accounts for about half of observed differences in investment rates between rich and poor countries. Although consumption should include a non-negligible tradable component, this parametrization provides an instructive upper bound for differences in investment rate that the model can generate when $\gamma = 0.4$, regardless of the assumed role for the two goods in consumption.

We conclude that with reasonable parameter values, the model cannot account for observed differences in investment rates. Decreasing relative productivity can, in fact, lead to higher rather than lower investment rates in poor countries, if elasticity of substitution between the two goods in consumption is less than unitary. The driving force behind our conclusions is the empirical finding that nontradables play a dominant role not only in consumption, but also in investment expenditures.

VII. CONCLUSIONS

Setting up a two-sector open economy growth model requires an assumption about the role of tradable and nontradable goods in the capital accumulation process. A common practice in the literature is to assume that only tradable goods can be transformed into investments or that the role of tradables and nontradables in investment is the same as in consumption. In a survey of the topic, Turnovsky (1997) concludes that `no one assumption has gained a uniform acceptance', since these assumptions are driven by mere convenience considerations rather than empirical facts. Furthermore, model results, especially quantitative ones, are often sensitive to the assumption used.

Although there is some variation across countries, we find that, on average, expenditures on nontradable and tradable goods account for 60 and 40 percent of investment expenditures, respectively. Furthermore, the investment expenditure shares on the two components have been

[25] We do not report the value of μ since it has no clear economic interpretation. As in the case with unitary elasticity of substitution, with the CES functional form for consumption aggregation, results in Figure 7 only depend on the relative productivity ratio $\frac{A_T}{A_N} / \frac{\widetilde{A}_T}{\widetilde{A}_N}$. Results are independent of the level of productivity in tradable and nontradable sectors, A_T and A_N. A change in the level of the productivity ratio, A_T / A_N, requires a change in μ, but otherwise does not affect results. See Appendix II for details.

close to constant over the last 50 years and exhibit a small positive correlation with the level of income. These results are remarkable, given the large and systematic variation in relative prices across both time and income levels.

Our empirical results suggest that a more realistic modeling of the capital accumulation process in two-sector models can be achieved with relatively little additional complexity, i.e. by assuming a unitary elasticity of substitution between the two investment components. Although in this paper we concentrate on the tradable-nontradable nature of sectoral output, our results are also applicable to models distinguishing between equipment and structures in investment.

Findings of this paper can have important implications for macro models. One such implication, applying our results to a steady state of a standard two-sector growth model, was presented in Section 6. Here we point out two additional applications. First, the exact mix of tradables and nontradables in investment and aggregate capital stock affects the speed of transitional dynamics in a two sector open economy growth model, with a larger share for nontradables slowing down the transition process. This can be a useful addition to the standard setup, where more plausible transitional dynamics are commonly achieved by assuming excessive frictions for production factors and/or prices.

Second, in addition to being nontradable, construction may play a special role in macro models, because real estate is the quintessential collateral asset. Our empirical results, including the finding that residential structures account for quarter of all investment expenditures, can be applied to models that include collateral constraints in both cross-country and time-series setting.

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Appendix I: Compatibility of national accounts and input-output table data

This appendix examines the compatibility of investment expenditure data in input-output tables and national accounts. In particular, we compare investment expenditure shares on the output of the manufacturing sector from the two data sources. The expenditure share is expected to be higher in national accounts, since expenditures on the same items are in basic prices in input-output tables, while in national accounts they are in purchaser's prices. The difference between the two stems from the added value of the distribution sector.

Table A1 compares the two expenditures for available country-year observations from input-output tables up to 1990. For 7 out of 9 countries we indeed find that expenditure shares are slightly higher in national accounts data, with the bias in 0.003-0.087 range. For the remaining two countries, Germany and Australia, differences are larger, suggesting that data from input-output tables and national accounts are not entirely compatible.

Table A2 makes the same comparisons using the latest input-output table data for OECD countries. As in the pre-1990 data, for majority of countries expenditure share is higher in national accounts data. Furthermore, the difference does not exceed 0.088, which is in line with the expenditure share on the output of the distribution sector.

Table A1: Comparison of investment expenditures on the output of manufacturing sector in input-output tables and national accounts, 1970-1990

Country	Data source\Period	Pre-1973	Mid/late-1970s	Early-1980s	Mid-1980s	1990
Australia	input-output tables	0.310	0.273		0.321	0.273
	national accounts	0.470	0.435		0.495	0.452
	difference	0.160	0.162		0.174	0.179
Denmark	input-output tables	0.259	0.331	0.329	0.410	0.399
	national accounts	0.306	0.370	0.372	0.468	0.460
	difference	0.047	0.039	0.043	0.058	0.061
France	input-output tables	0.322	0.321			
	national accounts	0.381	0.377			
	difference	0.059	0.056			
Germany	input-output tables		0.423	0.471	0.486	0.500
	national accounts		0.399	0.431	0.445	0.462
	difference		-0.024	-0.040	-0.041	-0.038
Italy	input-output tables			0.393		
	national accounts			0.466		
	difference			0.073		
Japan	input-output tables	0.360	0.276	0.265	0.338	0.311
	national accounts	0.433	0.342	0.326	0.402	0.398
	difference	0.073	0.066	0.061	0.064	0.087
Netherlands	input-output tables	0.319	0.342	0.324	0.422	
	national accounts	0.381	0.406	0.365	0.490	
	difference	0.062	0.064	0.041	0.068	
UK	input-output tables	0.427	0.472		0.437	0.400
	national accounts	0.454	0.494		0.470	0.437
	difference	0.027	0.022		0.033	0.037
USA	input-output tables	0.366	0.392	0.373	0.388	0.387
	national accounts	0.369	0.413	0.426	0.425	0.444
	difference	0.003	0.021	0.053	0.037	0.057

Sources: Table 1, UN (2001a,b).

Table A2: Comparison of investment expenditures on the output of manufacturing sector in input-output tables and national accounts, 1995-2001

Data source	Input-output tables	National accounts	Difference
Country, year			
USA, 1997	0.354	0.389	0.035
France, 2000	0.339	0.326	-0.013
Germany, 2000	0.420	0.399	-0.020
Austria, 2000	0.369	0.406	0.037
Denmark, 2000	0.336	0.403	0.067
Finland, 2000	0.315	0.303	-0.012
Hungary, 2000	0.378	0.466	0.088
Ireland, 1998	0.279	0.351	0.072
Italy, 2000	0.444	0.490	0.046
Netherlands, 2000	0.319	0.315	-0.004
Norway, 2001	0.342	0.323	-0.018
Poland, 2000	0.440	0.400	-0.040
Portugal, 1999	0.288	0.361	0.073
Spain, 1995	0.267	0.277	0.011
Sweden, 2000	0.435	0.486	0.051
Australia, 1994/95	0.274	0.361	0.088
Canada, 1997	0.324	0.366	0.042
Czech Rep., 1995	0.488	0.412	-0.076
Greece, 1998	0.282	0.349	0.068
Japan, 1995	0.280	0.360	0.081
Korea, 1995	0.410	0.378	-0.032
UK, 1998	0.422	0.499	0.077

Sources: Eurostat (2005), OECD (2002a), OECD (2006).

Appendix II: Two-sector model with tradables and nontradables

To keep the equations tractable, we first solve the model for the case of unitary elasticity of substitution in consumption and then show how results change if a more general CES aggregator for consumption is used.

Solution of the model, when $\theta = 1$

Consider a version of the model presented in Section 6, where instead of (17) consumption in aggregated using $F_C(c_T, c_N) = c_T^{\varepsilon} c_N^{1-\varepsilon}$, where ε is consumption expenditure share on tradables. The solution of such a model can be characterized by the following system of ten equations and ten unknowns

$$\begin{cases} \frac{1-\varepsilon}{\varepsilon}\frac{c_T}{c_N} - p_N = 0 \\ q(1-\gamma)Gi_T^{\gamma} i_N^{-\gamma} - p_N = 0 \\ q\gamma G i_T^{\gamma-1} i_N^{1-\gamma} - 1 = 0 \\ p_N \alpha A_N k_N^{\alpha-1} l_N^{1-\alpha} - q(r+\delta) = 0 \\ \alpha A_T k_T^{\alpha-1} l_T^{1-\alpha} - q(r+\delta) = 0 \\ G i_T^{\gamma} i_N^{1-\gamma} - \delta(k_T + k_N) = 0 \\ A_T k_T^{\alpha} l_T^{1-\alpha} - c_T - i_T = 0 \\ A_N k_N^{\alpha} l_N^{1-\alpha} - c_N - i_N = 0 \\ p_N A_N k_N^{\alpha} l_N^{-\alpha} - A_T k_T^{\alpha} l_T^{-\alpha} = 0 \\ L - l_T - l_N = 0. \end{cases} \tag{20}$$

Note that in this model foreign asset position, b, is treated as exogenous and is set equal to zero, L denotes the inelastic aggregate labor supply and q is the relative price of capital goods. To solve the system, we use equations 2, 3, 4, 5 and 9 in (20) to solve for

$$\begin{aligned} \frac{i_T}{i_N} &= \frac{A_T}{A_N}\frac{\gamma}{(1-\gamma)}, \\ p_N &= \frac{A_T}{A_N}, \\ q &= \left(\frac{A_T}{A_N}\right)^{1-\gamma}, \\ \frac{k_T}{l_T} &= \frac{k_N}{l_N} = \left[\frac{\alpha}{r+\delta} A_T^{\gamma} A_N^{1-\gamma}\right]^{\frac{1}{1-\alpha}}, \end{aligned} \tag{21}$$

where**,** without loss of generality, we have set $G^{-1} = \gamma^{\gamma}(1-\gamma)^{1-\gamma}$.

Next, substituting the expressions in (21) back into the remaining equations in (20), we solve for other variables of interest. First, from equation 6 in (20), we can directly solve for

$$i_N = A_N(1-\gamma)L\frac{\delta\alpha}{r+\delta}\left[\frac{\alpha}{r+\delta} A_T^{\gamma} A_N^{1-\gamma}\right]^{\frac{\alpha}{1-\alpha}}, \tag{22}$$

which combined with equation 1 in (21) implies that

$$i_T = A_T \gamma L \frac{\delta\alpha}{r+\delta}\left[\frac{\alpha}{r+\delta} A_T^{\gamma} A_N^{1-\gamma}\right]^{\frac{\alpha}{1-\alpha}}. \tag{23}$$

Equations 1, 7, 8 and 10 in (20) are then used to solve for

$$\begin{aligned}
l_N &= L - L\left(\gamma\frac{\delta\alpha}{r+\delta} + \varepsilon\left[1-\frac{\delta\alpha}{r+\delta}\right]\right),\\
l_T &= L\left(\gamma\frac{\delta\alpha}{r+\delta} + \varepsilon\left[1-\frac{\delta\alpha}{r+\delta}\right]\right),\\
c_T &= A_T L\varepsilon\left(1-\frac{\delta\alpha}{r+\delta}\right)\left[\frac{\alpha}{r+\delta} A_T^{\gamma} A_N^{1-\gamma}\right]^{\frac{\alpha}{1-\alpha}},\\
c_N &= A_N L(1-\varepsilon)\left(1-\frac{\delta\alpha}{r+\delta}\right)\left[\frac{\alpha}{r+\delta} A_T^{\gamma} A_N^{1-\gamma}\right]^{\frac{\alpha}{1-\alpha}},
\end{aligned} \tag{24}$$

and substituting expressions for l_N and l_T into (21), we obtain

$$\begin{aligned}
k_N &= L\left(1-\left(\gamma\frac{\delta\alpha}{r+\delta} + \varepsilon\left[1-\frac{\delta\alpha}{r+\delta}\right]\right)\right)\left[\frac{\alpha}{r+\delta} A_T^{\gamma} A_N^{1-\gamma}\right]^{\frac{1}{1-\alpha}},\\
k_T &= L\left(\gamma\frac{\delta\alpha}{r+\delta} + \varepsilon\left[1-\frac{\delta\alpha}{r+\delta}\right]\right)\left[\frac{\alpha}{r+\delta} A_T^{\gamma} A_N^{1-\gamma}\right]^{\frac{1}{1-\alpha}}.
\end{aligned} \tag{25}$$

Finally, we can solve for values of output and investments. Total output can be expressed as

$$\begin{aligned}
Y &= i_T + c_T + p_N c_N + p_N i_N,\\
Y &= A_T L\left[\frac{\alpha}{r+\delta} A_T^{\gamma} A_N^{1-\gamma}\right]^{\frac{\alpha}{1-\alpha}}.
\end{aligned} \tag{26}$$

Expressions for total investment are

$$\begin{aligned}
I &= i_T + p_N i_N,\\
I &= A_T L\frac{\delta\alpha}{r+\delta}\left[\frac{\alpha}{r+\delta} A_T^{\gamma} A_N^{1-\gamma}\right]^{\frac{\alpha}{1-\alpha}}.
\end{aligned} \tag{27}$$

Thus, investment rate is

$$\frac{I}{Y} = \frac{\delta\alpha}{r+\delta} \tag{28}$$

and the investment expenditure shares on nontradables is

$$\frac{p_N i_N}{I} = (1-\gamma). \tag{29}$$

It is also of interest to note here that total output is positively related to the sectoral productivity parameters

$$\begin{aligned}
\frac{\partial Y}{\partial A_T} &= \frac{1-\alpha(1-\gamma)}{1-\alpha}\frac{Y}{A_T} > 0,\\
\frac{\partial Y}{\partial A_N} &= \frac{\alpha(1-\gamma)}{1-\alpha}\frac{Y}{A_N} > 0.
\end{aligned} \tag{30}$$

Comparisons in common prices

To express model outcomes for varying relative productivities in common prices, we denote the common price by $p_N^{PPP} = \widetilde{A}_T/\widetilde{A}_N$ and consider the effect of productivity changes on quantities only. The expression for PPP adjusted investments is

$$\begin{aligned} I^{PPP} &= i_T + p_N^{PPP} i_N, \\ I^{PPP} &= \left(A_T\gamma + \frac{\widetilde{A}_T}{\widetilde{A}_N} A_N(1-\gamma) \right) L \frac{\delta\alpha}{r+\delta} \left[\frac{\alpha}{r+\delta} A_T^{\gamma} A_N^{1-\gamma} \right]^{\frac{\alpha}{1-\alpha}}. \end{aligned} \tag{31}$$

The ratio $\frac{p_N^{PPP} i_N}{I^{PPP}}$, which represents PPP adjusted expenditure share on nontradables, is

$$\frac{p_N^{PPP} i_N}{I^{PPP}} = \left(\frac{A_T}{A_N} \frac{\widetilde{A}_N}{\widetilde{A}_T} \frac{\gamma}{(1-\gamma)} + 1 \right)^{-1}. \tag{32}$$

We are interested in the sign of

$$\frac{\partial \frac{p_N^{PPP} x_N}{I^{PPP}}}{\partial \frac{A_T}{A_N}} = -\frac{\frac{\widetilde{A}_N}{\widetilde{A}_T} \frac{\gamma}{(1-\gamma)}}{\left(\frac{A_T}{A_N} \frac{\widetilde{A}_N}{\widetilde{A}_T} \frac{\gamma}{(1-\gamma)} + 1 \right)^2}, \tag{33}$$

which is negative, i.e., higher relative productivity in the tradable sector leads to investment being less intensive in nontradables. This is the same result as in (6).
The expression for PPP adjusted output is

$$\begin{aligned} Y^{PPP} &= i_T + c_T + p_N^{PPP} c_N + p_N^{PPP} i_N, \\ Y^{PPP} &= \left(\frac{\delta\alpha}{r+\delta} \left(A_T\gamma + \frac{\widetilde{A}_T}{\widetilde{A}_N} A_N(1-\gamma) \right) + \left(1 - \frac{\delta\alpha}{r+\delta} \right) \left(A_T\varepsilon + \frac{\widetilde{A}_T}{\widetilde{A}_N} A_N(1-\varepsilon) \right) \right) * \\ &\quad * L \left[\frac{\alpha}{r+\delta} A_T^{\gamma} A_N^{1-\gamma} \right]^{\frac{\alpha}{1-\alpha}}. \end{aligned} \tag{34}$$

We are interested in the sign of the derivative of the PPP adjusted output with respect to sectoral productivity

$$\frac{\partial Y^{PPP}}{\partial A_T} = \frac{1-\alpha(1-\gamma)}{1-\alpha} \Psi_1 A_T^{\frac{\gamma\alpha}{1-\alpha}} A_N^{\frac{\alpha(1-\gamma)}{1-\alpha}} + \frac{\gamma\alpha}{1-\alpha} \Psi_2 A_T^{\frac{\gamma\alpha-1+\alpha}{1-\alpha}} A_N^{\frac{1-\alpha\gamma}{1-\alpha}} > 0 \tag{35}$$

and

$$\frac{\partial Y^{PPP}}{\partial A_N} = \frac{\alpha(1-\gamma)}{1-\alpha} \Psi_1 A_T^{\frac{1-\alpha+\gamma\alpha}{1-\alpha}} A_N^{\frac{\alpha-\alpha\gamma-1+\alpha}{1-\alpha}} + \frac{1-\alpha\gamma}{1-\alpha} \Psi_2 A_T^{\frac{\gamma\alpha}{1-\alpha}} A_N^{\frac{\alpha-\alpha\gamma}{1-\alpha}} > 0, \tag{36}$$

where

$$\Psi_1 = \left(\gamma\frac{\delta\alpha}{r+\delta} + \varepsilon\left(1-\frac{\delta\alpha}{r+\delta}\right)\right)\left(\frac{\alpha}{r+\delta}\right)^{\frac{\alpha}{1-\alpha}} L > 0,$$
$$\Psi_2 = \left((1-\gamma)\frac{\delta\alpha}{r+\delta} + (1-\varepsilon)\left(1-\frac{\delta\alpha}{r+\delta}\right)\right)\left(\frac{\alpha}{r+\delta}\right)^{\frac{\alpha}{1-\alpha}} L\frac{\widetilde{A}_T}{\widetilde{A}_N} > 0. \tag{37}$$

PPP adjusted output is positively related to changes in either of the productivity parameters. With respect to changes in relative productivity, A_T / A_N, there is no clear relation, since it depends on the sign of the change in the level of A_T and A_N. For example, if only A_N or only A_T increases, then output will increase, but relative productivity move in opposite directions in the two scenarios.

The PPP adjusted investment ratio can be expressed as

$$\frac{I^{PPP}}{Y^{PPP}} = \frac{\frac{\alpha\delta}{r+\delta}\left[1-\gamma\left(1-\frac{A_T}{A_N}/\frac{\widetilde{A}_T}{\widetilde{A}_N}\right)\right]}{1-\left[\gamma\frac{\alpha\delta}{r+\delta}+\varepsilon\left(1-\frac{\alpha\delta}{r+\delta}\right)\right]\left(1-\frac{A_T}{A_N}/\frac{\widetilde{A}_T}{\widetilde{A}_N}\right)}. \tag{38}$$

We are interested in the sign of

$$\frac{\partial\frac{I^{PPP}}{Y^{PPP}}}{\partial\frac{A_T}{A_N}} = \frac{(\gamma-\varepsilon)\frac{\delta\alpha}{r+\delta}\left(1-\frac{\delta\alpha}{r+\delta}\right)\frac{\widetilde{A}_T}{\widetilde{A}_N}}{\left[1-\left[\gamma\frac{\alpha\delta}{r+\delta}+\varepsilon\left(1-\frac{\alpha\delta}{r+\delta}\right)\right]\left(1-\frac{A_T}{A_N}/\frac{\widetilde{A}_T}{\widetilde{A}_N}\right)\right]^2}, \tag{39}$$

which is positive if $\gamma > \varepsilon$ and negative if $\gamma < \varepsilon$. Thus, investment rate increases (decreases) in the relative productivity, if expenditure share on tradables in investment is higher (lower) than in consumption.

Allowing for CES aggregation in consumption

If instead of a unitary elasticity of substitution in consumption, the CES aggregator in (18) is used, all expressions in the above model solution are still valid, subject to the following substitution

$$\varepsilon = \left(\left(\frac{A_T}{A_N}\right)^{1-\theta}\left(\frac{1-\mu}{\mu}\right)^{\theta}+1\right)^{-1}. \tag{40}$$

Derivatives with respect to relative productivity will, of course, change and need to be evaluated numerically.

Table 1: Summary of data sources

Dataset	Type of data	Period of coverage	Countries covered	Usage	Level of detail for investment expenditures /1/	References
OECD Input-Output database, ed. 1995	Input-output tables	benchmark years for 1968-1990	Selected OECD (for details see Table 2)	Investment ependiture shares	By industry	OECD (1995a,b,c)
OECD Input-Output database, ed. 2002	Input-output tables	benchmark years for 1992-1998	OECD	Investment ependiture shares, tradability of sectoral output	By industry	OECD (2002a,b)
Eurostat Input-Output database, ed. 2002	Input-output tables	benchmark years for 1995-2005	EU, Norway (for details see Table 4)	Investment ependiture shares, tradability of sectoral output	By industry	Eurostat (2005)
BEA Input-Outpu Table, 1997	Input-output tables	1997 benchmark	USA	Investment ependiture shares, tradability of sectoral output	By industry	Lawson et al. (2002)
OECD annual detailed NA	GDP by expenditure, SNA 93	1970-2004	OECD	Investment expenditure shares, relative price of nontradables in investments	(i) products of agriculture, forestry, fishing and aquaculture [T], (ii) metal products and machinery [T], (iii) transport equipment [T], (iv) dwellings [N], (v) other buildings or structures [N] and (iv) other products [2/3 N, 1/3 T] /2/	OECD (2006)
Penn World Tables benchmarks	GDP by expenditure	1970, 1975, 1980, 1985 and 1996	16 to 115, depending on year	Investment expenditure shares, relative price of nontradables in investments, real income per capita	(i) construction [N] and (ii) machinery and equipment [T]; before 1996 up to 20 subcategories of GFCF, all related to machinery and equipment [T] or construction [N]	Summers et al. (1995), Heston et al. (2002)
Nehru-Dhareshwar dataset	GDP by expenditure	1987	42	Investment ependiture shares	(i) construction[N] and (ii) machinery and equipment [T]	Nehru and Dhareshwar (1993)
UN annual detailed NA	GDP by expenditure, SNA 68	1950-1997	9 to 80 (for details see Table 8)	Investment ependiture shares	(i) residential buildings [N], (ii) non-residential buildings [N], (iii) other construction and land development [N] and (iv) other [T]	United Nations (2001a,b)

1. T and N in square brackets indicate the classification of a particular expenditure type into tradables [T] and nontrdables [N].
2. Expenditures on other products largely overlap with expenditures on the output of the real estate/business services sector. In particular, such expenditures include intangible fixed assets (e.g., software, mineral exploration) and costs associated with the transfer of ownership of non-produced assets. Following the findings in Section 3, we define 2/3 of such expenditures as nontradable and 1/3 as tradables.

Table 2: Investment expenditures on the output of different sectors of economic activity, as a fraction of total expenditures, 1968-1990/1/

Country	Sector of economic activity	Pre-1973	Mid/late-1970s	Early-1980s	Mid-1980s	1990	Country average
Australia	Manufacturing	0.310	0.273		0.321	0.273	0.294
	Construction	0.544	0.618		0.555	0.618	0.584
	Retail/wholesale trade	0.068	0.057		0.069	0.057	0.063
	Real est./bus. services	0.017	0.018		0.041	0.018	0.024
	Other	0.062	0.034		0.013	0.034	0.036
Denmark	Manufacturing	0.259	0.331	0.329	0.410	0.399	0.346
	Construction	0.674	0.598	0.595	0.495	0.505	0.573
	Retail/wholesale trade	0.049	0.054	0.060	0.070	0.068	0.060
	Real est./bus. services	0.015	0.017	0.018	0.021	0.026	0.020
	Other	0.003	0.000	-0.003	0.004	0.002	0.001
France	Manufacturing	0.322	0.321				0.322
	Construction	0.606	0.607				0.607
	Retail/wholesale trade	0.029	0.027				0.028
	Real est./bus. services/2/	--	--				--
	Other	0.043	0.044				0.044
Germany	Manufacturing		0.423	0.471	0.486	0.500	0.470
	Construction		0.491	0.455	0.441	0.429	0.454
	Retail/wholesale trade		0.050	0.034	0.034	0.032	0.037
	Real est./bus. services		0.032	0.033	0.032	0.032	0.032
	Other		0.004	0.007	0.007	0.007	0.006
Italy	Manufacturing			0.393			0.393
	Construction			0.516			0.516
	Retail/wholesale trade			0.054			0.054
	Real est./bus. services			0.017			0.017
	Other			0.019			0.019
Japan	Manufacturing	0.360	0.276	0.265	0.338	0.311	0.310
	Construction	0.566	0.661	0.672	0.590	0.594	0.617
	Retail/wholesale trade	0.066	0.056	0.057	0.065	0.075	0.064
	Real est./bus. services	0.000	0.000	0.000	0.000	0.013	0.003
	Other	0.008	0.007	0.006	0.007	0.007	0.007
Netherlands	Manufacturing	0.319	0.342	0.324	0.422		0.352
	Construction	0.540	0.493	0.513	0.406		0.488
	Retail/wholesale trade	0.058	0.062	0.057	0.080		0.064
	Real est./bus. services	0.050	0.075	0.072	0.069		0.066
	Other	0.033	0.027	0.034	0.023		0.029
UK	Manufacturing	0.427	0.472		0.437	0.400	0.434
	Construction	0.458	0.381		0.477	0.470	0.447
	Retail/wholesale trade	0.008	0.043		0.019	0.038	0.027
	Real est./bus. services	0.062	0.050		0.046	0.080	0.059
	Other	0.045	0.054		0.021	0.013	0.033
USA/3/	Manufacturing	0.366	0.392	0.373	0.388	0.387	0.381
	Construction	0.536	0.479	0.519	0.498	0.465	0.500
	Retail/wholesale trade	0.055	0.078	0.068	0.074	0.074	0.070
	Real est./bus. services	0.022	0.032	0.025	0.023	0.038	0.028
	Other	0.021	0.019	0.015	0.017	0.037	0.022
Period average	Manufacturing	0.338	0.354	0.359	0.400	0.378	0.367
	Construction	0.561	0.541	0.545	0.495	0.513	0.532
	Retail/wholesale trade	0.047	0.053	0.055	0.059	0.057	0.052
	Real est./bus. services	0.028	0.032	0.028	0.033	0.034	0.031
	Other	0.027	0.020	0.013	0.013	0.017	0.019

Source: OECD (1995a).

3. Exact years of coverage for each country are: Australia - 1968, 1974, 1986, 1989; Denmark - 1972, 1977, 1980, 1985, 1990; France - 1972, 1977; Germany - 1978, 1986, 1988, 1990; Italy - 1985; Japan - 1970, 1975, 1980, 1985, 1990; Netherlands - 1972, 1977, 1981, 1986; UK - 1968,1979, 1984, 1990; United States - 1972, 1977, 1982, 1985, 1990. Data for Canada and France after 1980 are excluded from the table, since GFCF in input-output tables covered only a fraction of aggregate investment.
4. Expenditures on real estate/business services are included in 'other' sectors.
5. Data covers only private sector investment.

Table 3: Investment expenditures on the output of different sectors of economic activity, as a fraction of total expenditures, USA, 1997/1/

Sector of economic activity		Expenditure share
Manufacturing		0.354
Construction		0.426
Retail and wholesale trade		0.073
Real estate and business services,		0.121
of which:	*Real estate services*	*0.028*
	Computer system design and related services	*0.056*
	Software	*0.023*
	Other business services	*0.014*
Other		0.026

Source: BEA input-output benchmark table, 1997 (see Lawson et al. (2002)).

1. To make results compatible with SNA93 definitions, investment includes private and government investment, except military expenditures.

Table 4: Investment expenditures on the output of different sectors of economic activity, as a fraction of total expenditures, 1998-2001/1/

Country	UK	Poland	Norway	Italy	Hungary	Greece
Year	1998	2000	2001	2000	2000	1998
Sector of economic activity						
Manufacturing	0.422	0.440	0.342	0.444	0.378	0.282
Construction	0.410	0.370	0.329	0.401	0.416	0.634
Retail/wholesale trade	0.048	0.092	0.051	0.063	0.070	0.057
Real est./bus. services	0.090	0.084	0.191	0.068	0.117	0.020
Other	0.030	0.015	0.088	0.024	0.019	0.008

Country	France	Netherlands	Ireland	Finland	Denmark	Germany
Year	2000	2000	1998	2000	2000	2000
Sector of economic activity						
Manufacturing	0.339	0.319	0.279	0.315	0.336	0.420
Construction	0.436	0.428	0.568	0.511	0.440	0.428
Retail/wholesale trade	0.036	0.074	0.082	0.007	0.093	0.038
Real est./bus. services	0.174	0.117	0.065	0.124	0.102	0.087
Other	0.016	0.063	0.007	0.043	0.029	0.027

Country	Austria	Belgium	Portugal	Slovenia	Sweden	Average
Year	2000	2000	1999	2000	2000	
Sector of economic activity						
Manufacturing	0.369	0.436	0.288	0.396	0.435	**0.367**
Construction	0.436	0.390	0.507	0.474	0.260	**0.438**
Retail/wholesale trade	0.104	0.091	0.091	0.052	0.073	**0.066**
Real est./bus. services	0.080	0.077	0.095	0.066	0.223	**0.105**
Other	0.012	0.006	0.019	0.011	0.009	**0.025**

Source: Eurostat (2005).

1. Included in the table are all countries with an input-output table available for year 1998 or later.

Table 5: Tradability of sectoral output for selected countries/1/

Sector	Retail and wholesale trade	Construction		Real estate and business services		Manufacturing	
Country, year of input-output table							
USA, 1997	0.04	0.00	N	0.02	N	0.29	T
France, 2000	0.10	0.00	N	0.07	N	0.54	T
Germany, 2000	0.09	0.02	N	0.06	N	0.62	T
Austria, 2000	0.13	0.04	N	0.13	N	0.77	T
Belgium, 2000	0.24	0.03	N	0.22	N	0.92	T
Denmark, 2000	0.28	0.00	N	0.07	N	0.79	T
Estonia, 1997	0.14	0.10	N	0.22	T	0.80	T
Finland, 2000	0.02	0.00	N	0.13	T	0.62	T
Hungary, 2000	0.13	0.02	N	0.09	N	0.78	T
Ireland, 1998	0.51	0.00	N	0.59	T	0.90	T
Italy, 2000	0.09	0.00	N	0.07	N	0.48	T
Netherlands, 2000	0.20	0.02	N	0.26	T	0.95	T
Norway, 2001	0.14	0.01	N	0.16	T	0.60	T
Poland, 2000	0.15	0.09	N	0.06	N	0.51	T
Portugal, 1999	0.03	0.00	N	0.07	T	0.62	T
Slovenia, 2000	0.05	0.03	N	0.12	T	0.75	T
Spain, 1995	0.07	0.00	N	0.10	T	0.41	T
Sweden, 2000	0.21	0.00	N	0.18	N	0.71	T
Australia, 1994/95	0.07	0.00	N	0.03	N	0.39	T
Brazil, 1996	0.02	0.00	N	0.03	T	0.18	T
Canada, 1997	0.09	0.00	N	0.13	T	0.70	T
China, 1997	0.11	0.00	N	0.02	N	0.21	T
Czech Rep., 1995	0.07	0.05	N	0.25	T	0.57	T
Greece, 1994	0.07	0.00	N	0.02	N	0.49	T
Japan, 1995	0.03	0.00	N	0.02	N	0.19	T
Korea, 1995	0.09	0.00	N	0.05	N	0.38	T
UK, 1998	0.10	0.00	N	0.11	T	0.52	T
Sample mean/median	0.12/0.09	0.02/0.00		0.12/0.09		0.58/0.60	

Sources: Eurostat(2005); for Australia, Brazil, Canada, China, Czech Rep., Greece, Japan, Korean and UK data from OECD (2002a); for USA data from BEA input-output benchmark table, 1997.

1. Tradability is defined as sectoral (imports + exports)/(gross output). 'N' stands for 'Nontradable' and indicates that sector's tradability is lower than tradability of the retail/wholesale trade sector in the same country. The opposite case in denoted by 'T', which stands for 'Tradable'.

Table 6: Summary of aggregate investment expenditures on nontradable goods, 1970-2000/1/

Period	Pre-1973	Mid/late-1970s	Early-1980s	Mid-1980s	1990	Mid-1990s	2000
Expenditure share	0.64	0.63	0.63	0.59	0.61	0.61	0.59

Source: Author's calculations.

1. Until 1990 expenditure share obtained from period averages in Table 2, assuming that expenditures on the output of construction sector, distribution sector and 2/3 of real estate business sector are expenditures on nontradable goods. Results for 2000 obtained by applying the same definitions to the average expenditure shares in Table 4. Results for mid-1990s obtained by applying the same definitions to the relevant input-output table data from Eurostat (2005) and OECD (2002a). Mid-1990s also include data for the U.S. from Table 3.

Table 7: Summary statistics for investment expenditures on nontradable goods, OECD data

Country	Years of coverage	Mean	Standard deviation	Max	Min	Time trend, per decade/1/	Newey-West standard error
Australia	1970-2004	0.61	0.032	0.66	0.52	0.025*	0.006
Austria	1976-2004	0.59	0.019	0.63	0.57	0.005	0.005
Canada	1970-2004	0.66	0.031	0.70	0.59	-0.024*	0.006
Czech Republic	1990-2003	0.54	0.054	0.62	0.46		
Denmark	1970-2004	0.59	0.056	0.70	0.52	-0.046*	0.010
Finland	1970-2004	0.62	0.026	0.68	0.58	0.008	0.007
France	1978-2004	0.63	0.023	0.68	0.60		
Germany	1970-2004	0.61	0.029	0.67	0.56	-0.008	0.006
Greece	1995-2004	0.62	0.027	0.67	0.59		
Hungary	2000-2004	0.54	0.026	0.57	0.50		
Iceland	1990-2004	0.67	0.049	0.76	0.60		
Ireland	1990-2004	0.65	0.062	0.77	0.56		
Italy	1970-2004	0.53	0.029	0.60	0.48	-0.018*	0.006
Japan	1980-2003	0.61	0.020	0.66	0.59		
Korea	1970-2004	0.59	0.053	0.71	0.51	0.021	0.013
Luxembourg	1985-2003	0.58	0.051	0.70	0.51		
Netherlands	1970-2004	0.64	0.031	0.69	0.58	-0.011	0.008
New Zealand	1971-2004	0.55	0.033	0.59	0.48	0.000	0.009
Norway	1970-2004	0.67	0.046	0.75	0.55	0.027*	0.011
Poland	1995-2003	0.58	0.021	0.62	0.56		
Portugal	1988-2004	0.59	0.029	0.64	0.54		
Slovak Republic	1993-2004	0.42	0.047	0.48	0.35		
Spain	1980-2004	0.64	0.030	0.70	0.60		
Sweden	1980-2004	0.53	0.049	0.61	0.44		
Switzerland	1990-2003	0.50	0.025	0.55	0.47		
United Kingdom	1970-2004	0.53	0.029	0.60	0.47	-0.001	0.009
United States	1970-2004	0.60	0.023	0.65	0.56	-0.010	0.008
Average		0.59	0.035	0.65	0.53		

Source: OECD (2006).

1. Calculated for countries with at least 30 annual observations. The time trend reports the estimate of $10*\beta$ from the regression: $\gamma_t=\alpha+\beta t+\varepsilon_t$, where t denotes years. * indicates that the time trend is significantly different from zero at the 5% confidence level. Note also that the slope of expenditure shares is multiplied by 10 and should therefore be interpreted as a change in expenditure share over a decade. The N-W standard error is also multiplied by 10.

Table 8: Summary statistics for investment expenditures on nontradable goods, UN data

Country	Years of coverage	Mean	Standard deviation	Max	Min	Time trend, per decade/1/	Newey-West standard error
Algeria	1970-83	0.54	0.048	0.63	0.46		
Angola	1985-90	0.45	0.032	0.50	0.40		
Australia	1959-96	0.54	0.021	0.60	0.49	-0.006	0.004
Austria	1954-96	0.54	0.024	0.58	0.47	0.015*	0.005
Azerbaijan	1994-96	0.73	0.046	0.76	0.68		
Bahamas	1989-92	0.34	0.007	0.35	0.33		
Bangladesh	1972-87	0.63	0.076	0.79	0.52		
Belgium	1960-97	0.59	0.050	0.68	0.49	-0.026*	0.010
Bermuda	1979-92	0.52	0.055	0.66	0.42		
Bhutan	1980-96	0.58	0.132	0.79	0.40		
Bolivia	1960-69, 88-92	0.48	0.071	0.61	0.36		
Botswana	1971, 73-89, 91-92	0.56	0.107	0.73	0.42		
Brazil	1980-89	0.68	0.025	0.72	0.64		
Brunei Darussalam	1974-84	0.83	0.065	0.92	0.74		
Cambodia	1993-96	0.73	0.075	0.83	0.66		
Cameroon	1971-88	0.56	0.053	0.69	0.48		
Canada	1950-97	0.68	0.025	0.73	0.63	-0.009	0.005
Cape Verde	1980-89	0.66	0.035	0.70	0.59		
Chile	1974-96	0.57	0.070	0.74	0.47		
Hong Kong	1961-97	0.40	0.041	0.50	0.30	-0.000	0.006
Colombia	1960-95	0.58	0.041	0.66	0.49	-0.022*	0.005
Cote d Ivoire	1970-82	0.64	0.041	0.71	0.58		
Croatia	1994-96	0.59	0.026	0.62	0.57		
Cyprus	1960-96	0.65	0.059	0.74	0.53	0.041*	0.006
Czech Republic	1987-91	0.59	0.035	0.63	0.55		
Denmark	1966-95	0.60	0.066	0.70	0.49	-0.070*	0.007
Dominica	1971,73, 78-91	0.52	0.092	0.68	0.39		
Ecuador	1970-93	0.55	0.073	0.68	0.42		
Egypt	1960-79	0.46	0.031	0.51	0.42		
El Salvador	1963-89	0.44	0.061	0.60	0.35		
Equatorial Guinea	1985-91	0.43	0.121	0.64	0.29		
Ethiopia	1970-75	0.67	0.019	0.71	0.65		
Fiji	1970-72	0.54	0.022	0.57	0.52		
Finland	1960-96	0.62	0.028	0.68	0.55	-0.008	0.008
France	1970-97	0.59	0.035	0.65	0.54		
Gabon	1974	0.63		0.63	0.63		
Gambia	1970-71,74,93	0.64	0.132	0.86	0.38		
Germany	1991-97	0.61	0.041	0.64	0.53		
Germany, Federal Rep. of	1960-94	0.61	0.035	0.66	0.53	-0.025*	0.007
Ghana	1955-85	0.68	0.060	0.81	0.57	-0.013	0.013
Greece	1960-95	0.63	0.050	0.72	0.53	-0.043*	0.003
Guadeloupe	1965-69	0.66	0.029	0.70	0.63		
Guatemala	1950-96	0.41	0.115	0.67	0.26	-0.065*	0.007
Iceland	1960-96	0.72	0.045	0.82	0.62	-0.009	0.008
India	1950-96	0.56	0.078	0.75	0.42	-0.053*	0.003
Iran	1965-95	0.67	0.091	0.84	0.50	0.006	0.020
Iraq	1970-75,87-89	0.64	0.087	0.78	0.55		
Ireland	1970-96	0.53	0.047	0.64	0.45		
Israel	1950-97	0.61	0.089	0.83	0.43	-0.052*	0.006
Italy	1960-97	0.56	0.047	0.65	0.48	-0.032*	0.009
Jamaica	1974-90	0.52	0.050	0.63	0.43		
Japan	1970-96	0.63	0.030	0.67	0.57		
Jordan	1959-96	0.70	0.086	0.87	0.51	0.007	0.011
Kazakhstan	1990-96	0.89	0.048	0.93	0.82		
Kenya	1970-95	0.47	0.073	0.59	0.24		
Kuwait	1970-81	0.56	0.098	0.68	0.37		
Kyrgyzstan	1990-96	0.97	0.027	0.99	0.91		
Lesotho	1964-96	0.66	0.125	0.89	0.45	0.093*	0.021
Libyan Arab Jamahiriya	1971-79	0.67	0.016	0.69	0.64		
Luxembourg	1970-79	0.64	0.051	0.72	0.58		
Malawi	1970-72	0.44	0.044	0.49	0.41		

Table 8: continued

Country	Years of coverage	Mean	Standard deviation	Max	Min	Time trend, per decade/1/	Newey-West standard error
Malaysia	1960-71,73,78,83	0.63	0.080	0.72	0.51		
Malta	1970-97	0.37	0.079	0.57	0.27		
Mauritius	1970-97	0.57	0.070	0.70	0.40		
Mexico	1970-96	0.55	0.033	0.60	0.49		
Montserrat	1975-86	0.60	0.075	0.74	0.49		
Morocco	1960-69	0.60	0.026	0.64	0.55		
Namibia	1987-96	0.63	0.056	0.72	0.52		
Nepal	1977-81	0.76	0.033	0.79	0.71		
Netherlands	1969-97	0.57	0.039	0.64	0.51		
New Zealand	1971-96	0.53	0.037	0.59	0.47		
Nicaragua	1970-78	0.43	0.045	0.50	0.37		
Nigeria	1974-94	0.52	0.171	0.75	0.21		
Norway	1960-96	0.59	0.056	0.66	0.47	0.046*	0.009
Oman	1981-95	0.79	0.052	0.86	0.68		
Pakistan	1975-89	0.50	0.073	0.64	0.43		
Panama	1950-79	0.58	0.047	0.66	0.49	0.000	0.009
Paraguay	1962-94	0.54	0.086	0.78	0.43	0.040*	0.014
Peru	1970-97	0.64	0.093	0.78	0.48		
Philippines	1950-97	0.54	0.083	0.71	0.37	-0.032*	0.006
Portugal	1970-95	0.53	0.050	0.65	0.45		
Puerto Rico	1950-96	0.63	0.072	0.76	0.50	-0.037*	0.005
Republic of Korea	1960-97	0.59	0.057	0.69	0.50	-0.004	0.015
Saint Kitts and Nevis	1973,75	0.34	0.045	0.37	0.31		
St. Vincent & Grenadines	1977-97	0.66	0.072	0.77	0.49		
Saudi Arabia	1963-97	0.74	0.031	0.83	0.71		
Seychelles	1976-90	0.51	0.114	0.64	0.27		
Sierra Leone	1970-90	0.55	0.067	0.70	0.41		
Singapore	1970-97	0.47	0.075	0.63	0.39		
Slovenia	1990-95	0.46	0.048	0.54	0.42		
South Africa	1963-97	0.53	0.057	0.60	0.39	-0.036*	0.003
Spain	1980-96	0.67	0.028	0.73	0.63		
Sri Lanka	1963-97	0.61	0.086	0.74	0.41	-0.059*	0.006
Sudan	1970-83	0.46	0.100	0.66	0.31		
Suriname	1975-94	0.57	0.100	0.76	0.36		
Sweden	1970-96	0.58	0.051	0.67	0.46		
Switzerland	1950-96	0.61	0.046	0.68	0.53	-0.022*	0.006
Syrian Arab Republic	1963-97	0.59	0.111	0.81	0.40	-0.003	0.017
Thailand	1960-96	0.52	0.055	0.60	0.40	-0.009	0.007
Togo	1970-72	0.54	0.044	0.59	0.50		
Tonga	1975-83	0.66	0.069	0.77	0.57		
Trinidad and Tobago	1966-94	0.41	0.091	0.63	0.27		
Tunisia	1962-69	0.65	0.030	0.71	0.62		
Turkey	1960-97	0.61	0.064	0.75	0.50	-0.018	0.012
Uganda	1970-76,81-95	0.62	0.060	0.73	0.47		
United Kingdom	1963-96	0.54	0.021	0.59	0.50	-0.003	0.005
United Rep. of Tanzania	1970-94	0.41	0.141	0.67	0.20		
United States	1960-97	0.59	0.040	0.66	0.52	-0.034*	0.003
Uruguay	1966-89	0.69	0.076	0.82	0.58	0.061	0.030
Venezuela	1970-95	0.56	0.035	0.64	0.49		
Yugoslavia	1974	0.74		0.74	0.74		
Zambia	1970-91	0.41	0.095	0.52	0.22		
Zimbabwe	1970-89	0.52	0.079	0.63	0.34		
Average		0.58	0.061	0.69	0.48		

Data source: UN (2001a, b).

1. See notes to Table 7.

Table 9: Correlation between expenditure shares on nontradables, UN data

# of countries included	Period	1950-59	1960-69	1970-79	1980-89	1990-97
13	1950-59	1				
44	1960-69	0.649	1			
91	1970-79	0.452	0.863	1		
91	1980-89	0.527	0.555	0.643	1	
80	1990-97	0.307	0.630	0.492	0.735	1

Data sources: UN (2001a, b).

Table 10: Pooled time trends for sample countries with at least 30 annual observations/1/

Type of regression	Sample	# of observations	Time trend, per decade	Standard error
	Panel 1: OECD data			
Pooled OLS	OECD countries	448	-0.003	0.003
Panel with country dummies	OECD countries	448	-0.003	0.002
	Panel 2: UN data			
Pooled OLS	all countries	1335	-0.014*	0.002
	OECD countries	610	-0.014*	0.002
	Non-OECD countries	725	-0.016*	0.003
Panel with country dummies	all countries	1335	-0.017*	0.002
	OECD countries	610	-0.012*	0.001
	Non-OECD countries	725	-0.020*	0.003

Data sources: OECD (2006), UN (2001a, b).

1. In case of pooled OLS, time trend reports the estimate of 10*β from the regression: $\gamma_t=\alpha+\beta t+\varepsilon_t$, where t denotes years. In case of a panel with country dummies, the time trend reports the estimate of 10*β from the regression: $\gamma_t = \alpha+\beta t+d_i+\varepsilon_t$, where d_i is a country dummy. * indicates that the time trend is significantly different from zero at the 5% confidence level. Note also that the slope of expenditure shares is multiplied by 10 and should therefore be interpreted as a change in expenditure share over a decade. The N-W standard error is also multiplied by 10.

Table 11: Cross-section comparison of investment expenditures on nontradable goods, UN data, 1950-1997

Year	# of countries included	Mean	Correlation with real income per capita/1/	OLS coefficient /2/	Robust standard error/2/
1950	9	0.68	-0.31	-0.030	0.014
1951	9	0.68	-0.13	-0.010	0.018
1952	9	0.65	-0.21	-0.015	0.012
1953	9	0.64	-0.12	-0.015	0.015
1954	10	0.62	0.22	0.005	0.027
1955	11	0.63	0.15	0.007	0.026
1956	11	0.63	0.15	0.003	0.021
1957	11	0.62	0.14	0.011	0.023
1958	11	0.62	0.10	0.000	0.031
1959	13	0.61	0.04	-0.002	0.021
1960	30	0.60	0.07	0.005	0.016
1961	31	0.60	0.12	0.011	0.017
1962	33	0.60	0.09	0.009	0.018
1963	37	0.60	0.06	0.003	0.016
1964	38	0.60	0.07	0.001	0.016
1965	40	0.60	0.10	0.005	0.017
1966	42	0.60	0.14	0.012	0.016
1967	43	0.59	0.14	0.010	0.016
1968	43	0.59	0.18	0.019	0.016
1969	44	0.58	0.27	0.028	0.014
1970	71	0.56	0.28	0.022*	0.010
1971	76	0.56	0.32*	0.024*	0.009
1972	73	0.58	0.26	0.017	0.012
1973	74	0.58	0.23	0.009	0.011
1974	77	0.59	0.19	0.006	0.011
1975	81	0.57	0.28	0.014	0.011
1976	78	0.57	0.25	0.011	0.011
1977	79	0.57	0.19	0.006	0.011
1978	81	0.56	0.30*	0.025*	0.012
1979	80	0.58	0.24	0.018	0.013
1980	80	0.59	0.08	0.005	0.012
1981	82	0.60	-0.01	-0.004	0.012
1982	80	0.60	-0.03	-0.001	0.012
1983	80	0.60	0.01	0.005	0.011
1984	76	0.58	0.06	0.009	0.011
1985	77	0.57	0.02	0.008	0.013
1986	76	0.55	0.14	0.024	0.014
1987	79	0.55	0.18*	0.029*	0.013
1988	79	0.54	0.15	0.024	0.013
1989	79	0.54	0.13	0.020	0.015
1990	74	0.54	0.26*	0.034*	0.016
1991	72	0.55	0.16	0.025	0.017
1992	68	0.56	0.16	0.027	0.019
1993	65	0.57	0.11	0.021	0.023
1994	66	0.56	0.00	0.011	0.024
1995	59	0.57	-0.15	-0.027	0.026
1996	48	0.58	-0.23	-0.040	0.025
1997	21	0.52	0.08	0.019	0.037
	Average	0.58	0.10		

Data sources: UN (2001a, b), real GDP data from Heston et al. (2002).

1. * indicates that the correlation coefficient is significantly different from zero at 5% confidence level.
2. For each year the two columns report the coefficient and robust standard error from an OLS regression of nontradable investment expenditure share on the log of real income per capita. * indicates that the coefficient for the explanatory variable is significantly different from zero at 5% confidence level.

Table 12: Cross-section comparison of investment expenditures on nontradable goods, PWT benchmark data

Data set	# of countries included	Mean	Correlation with real income per capita
PWT 1996 benchmark/1/	115	0.51	0.12
-only A,B	*33*	*0.56*	*0.03*
-only A	*18*	*0.56*	*0.10*
Nehru-Dhareshwar dataset, 1987	42	0.56	0.13
PWT 1985 benchmark	65	0.56	0.04
PWT 1980 benchmark	60	0.58	0.31
PWT 1975 benchmark	34	0.57	0.53
PWT 1970 benchmark	16	0.56	0.13

Sources: Heston et al. (2002), Summers et al. (1995).

1. A, B, C and D refer to data quality, with A representing the highest and D the lowest quality. See Penn World Table 6.1 benchmark for details.

Table 13: Investment expenditure share on nontradable goods by region, PWT 1996 benchmark data

Region	# of countries included	Average expenditure share
Western Europe and North America/1/	25	0.56
Africa	22	0.23
-Africa, PWT 1985	*22*	*0.54*
-Africa, PWT 1980	*15*	*0.57*
Eastern and Central Europe/2/	26	0.59
Asia	12	0.59
Caribbean	12	0.51
Latin America	10	0.57
Middle East	8	0.57

Source: Heston et al. (2002).

1. Includes Japan, Australia and New Zealand.
2. Includes all former republics of the Soviet Union.

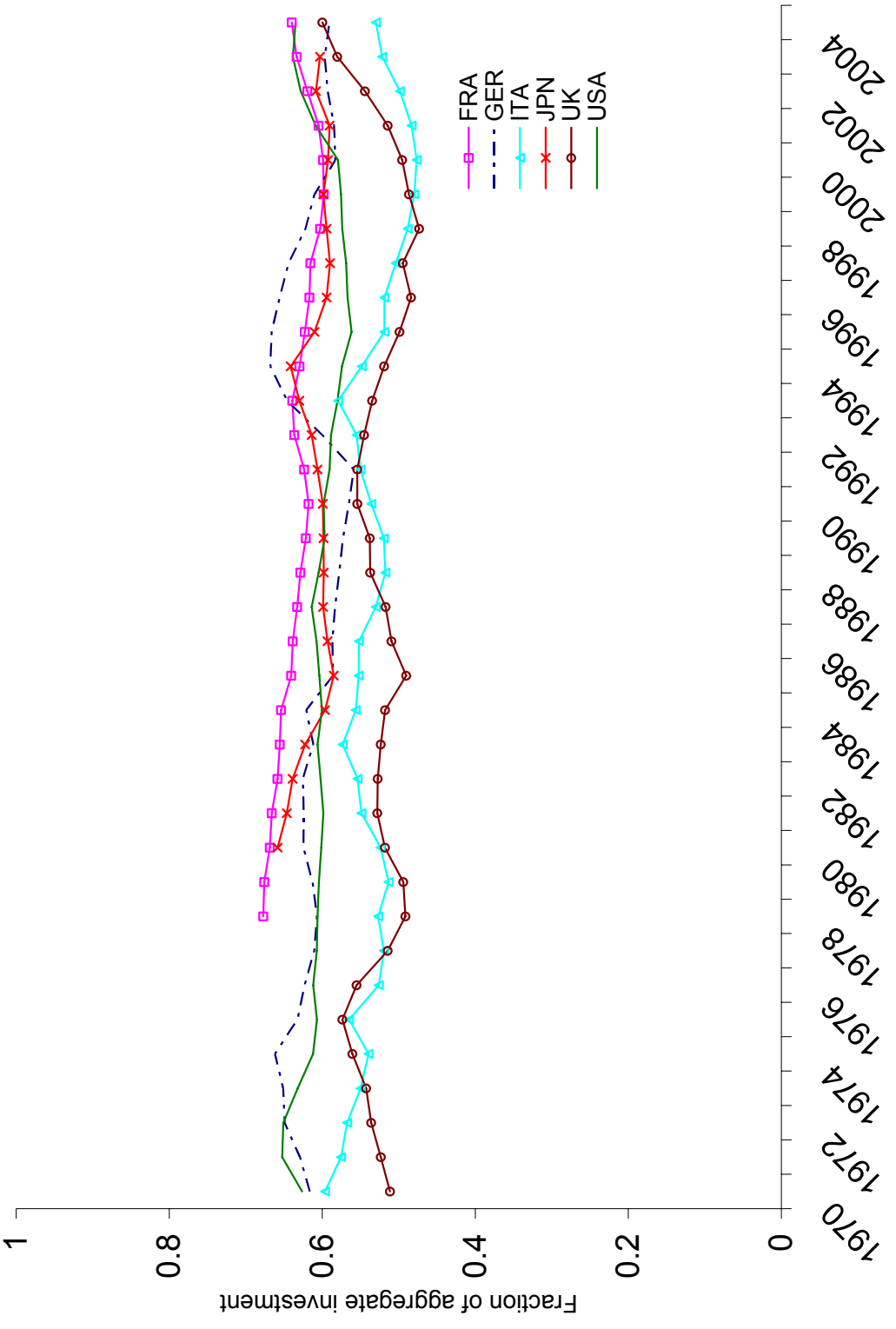
Table 14: Comparison of aggregate investment expenditure shares on construction in Burstein et al. (2004) and OECD national accounts data

Country	Year	Real GDP/ capita	Expenditure share, Burstein et al. (2004)	Expenditure share, OECD NA data/1/
Korea	1993	11940	0.540	0.639
Mexico	1990	7429	0.485	0.502
Brazil	1999	6909	0.674	0.669
Argentina	1997	11349	0.542	0.635
Australia	1995	22164	0.500	0.566
Canada	1990	22427	0.526	0.639
Chile	1996	8972	0.596	0.510
Denmark	1998	25495	0.457	0.469
Finland	1995	18852	0.458	0.524
France	1995	20142	0.485	0.498
Germany	1995	21049	0.494	0.640
Greece	1996	12751	0.647	0.645
Italy	1992	19810	0.498	0.498
Japan	1995	23361	0.573	0.552
Netherlands	1996	21431	0.432	0.538
Norway	1997	26178	0.346	0.409/2/
Spain	1995	16296	0.564	0.572
UK	1998	21693	0.410	0.427
US	1997	30286	0.423	0.485
Correlation with real GDP/capita			-0.69	-0.49

Sources: Burstein et al. (2004), OECD (2006), Heston et al. (2002).

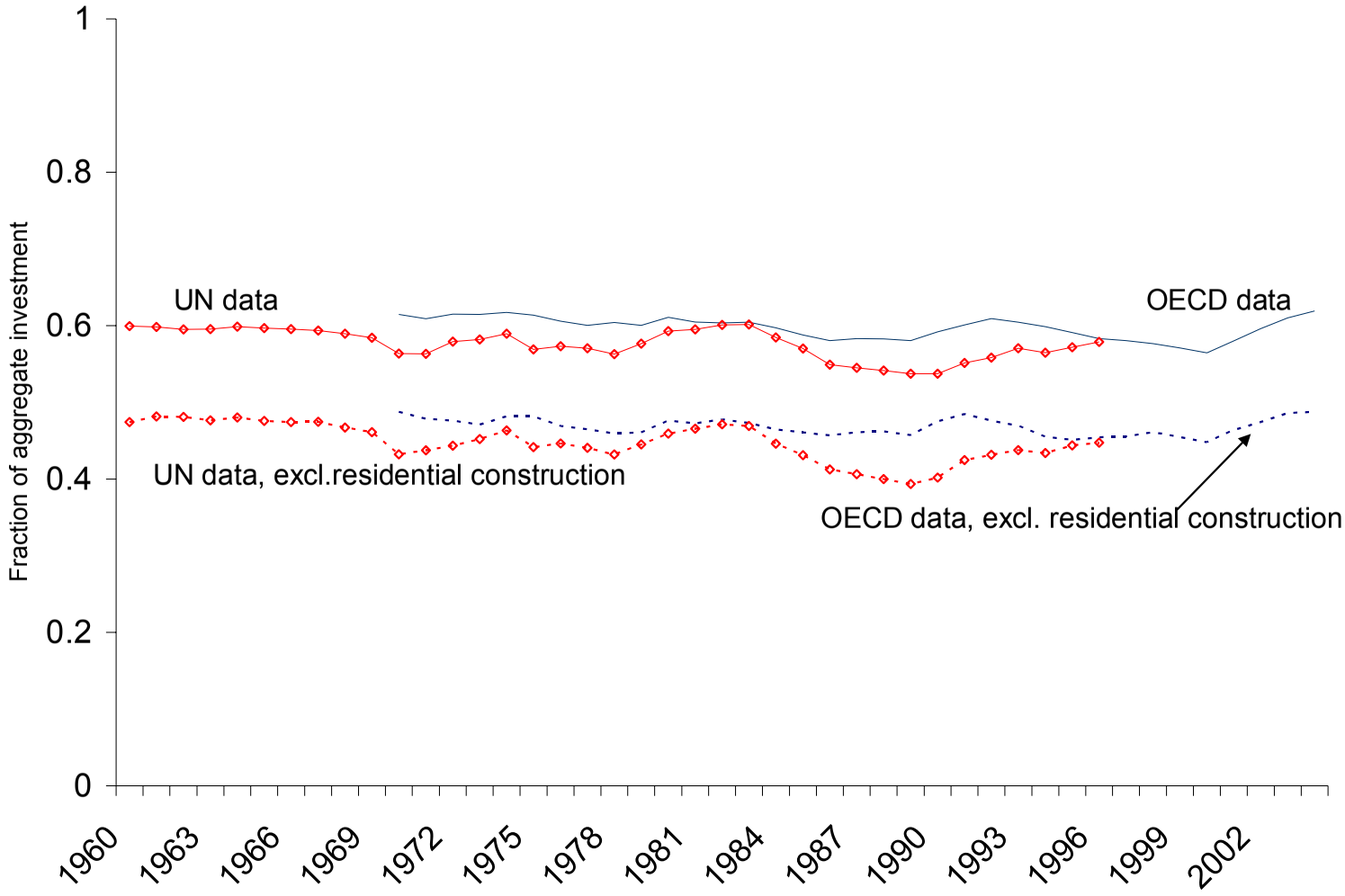
1. For non-OECD countries investment shares were obtained from PWT 1996 benchmark data.
2. Excluding oil rigs and oil exploration related expenditures.

Figure 1: Investment expenditure share on nontradables in selected countries



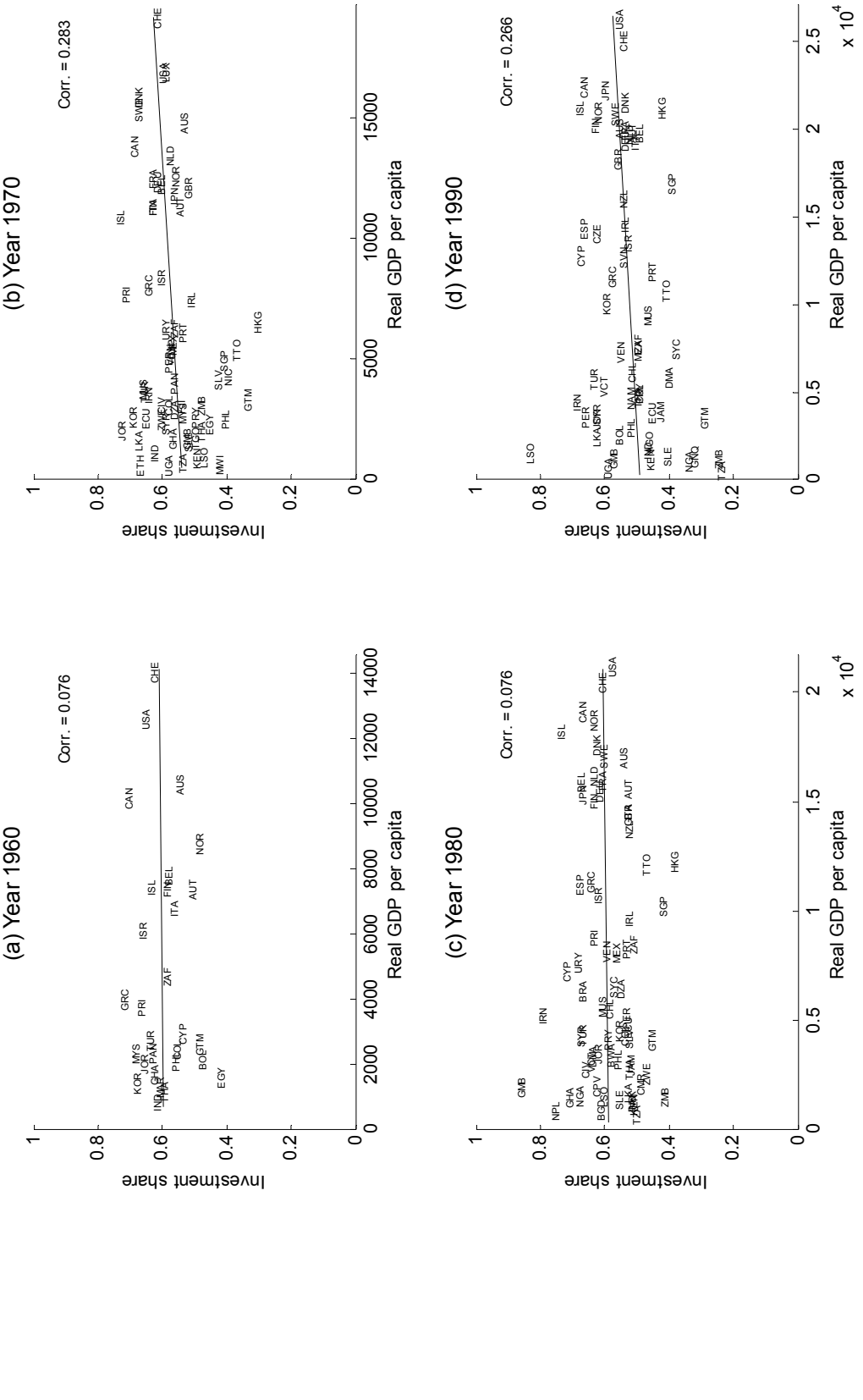
Source: OECD (2006).

Figure 2: Investment expenditure share on nontradables when residential construction is excluded from investment, cross-section averages



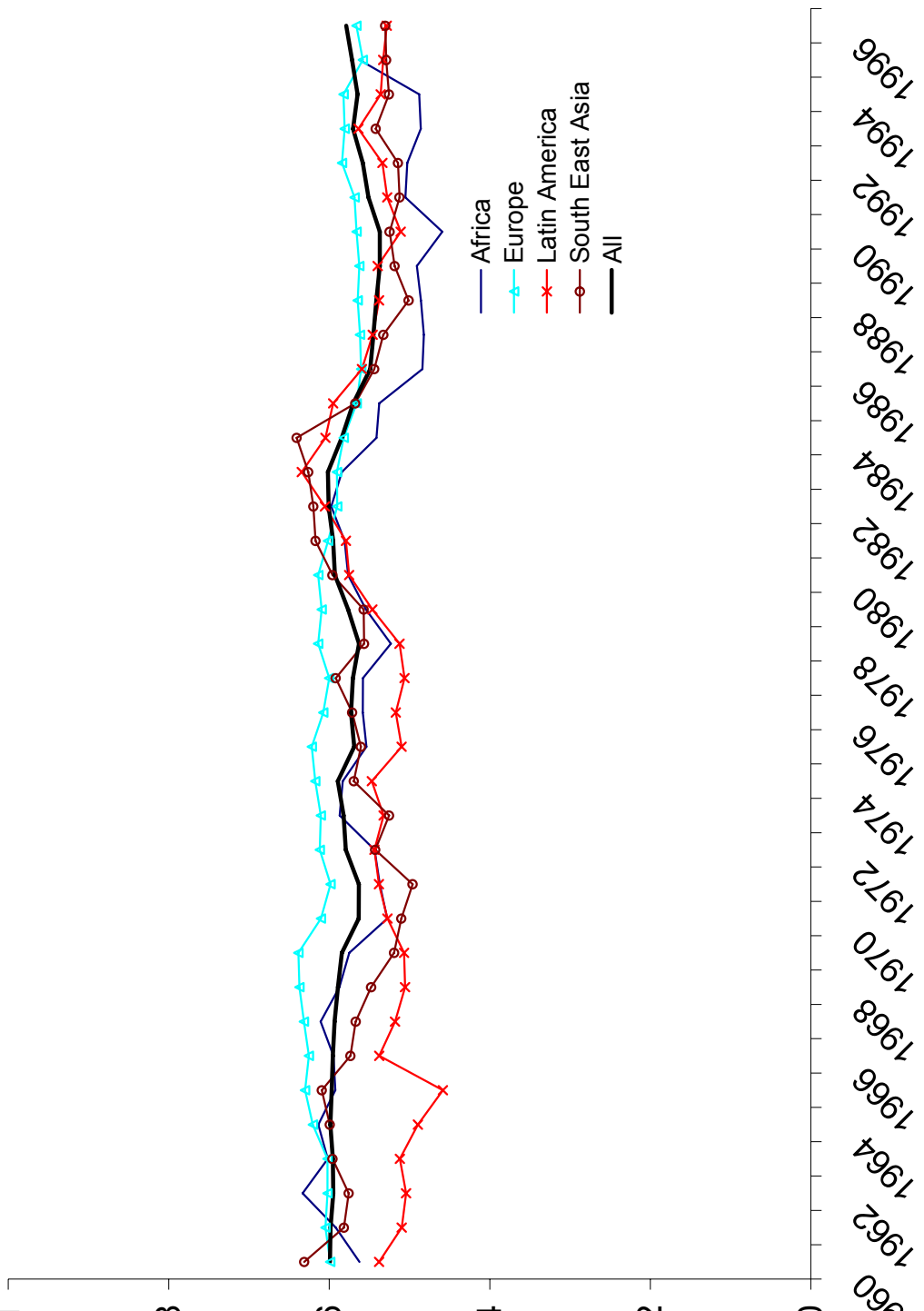
Sources: OECD (2006) and UN (2001a, b).

Figure 3: Investment expenditure share on nontradables for selected years



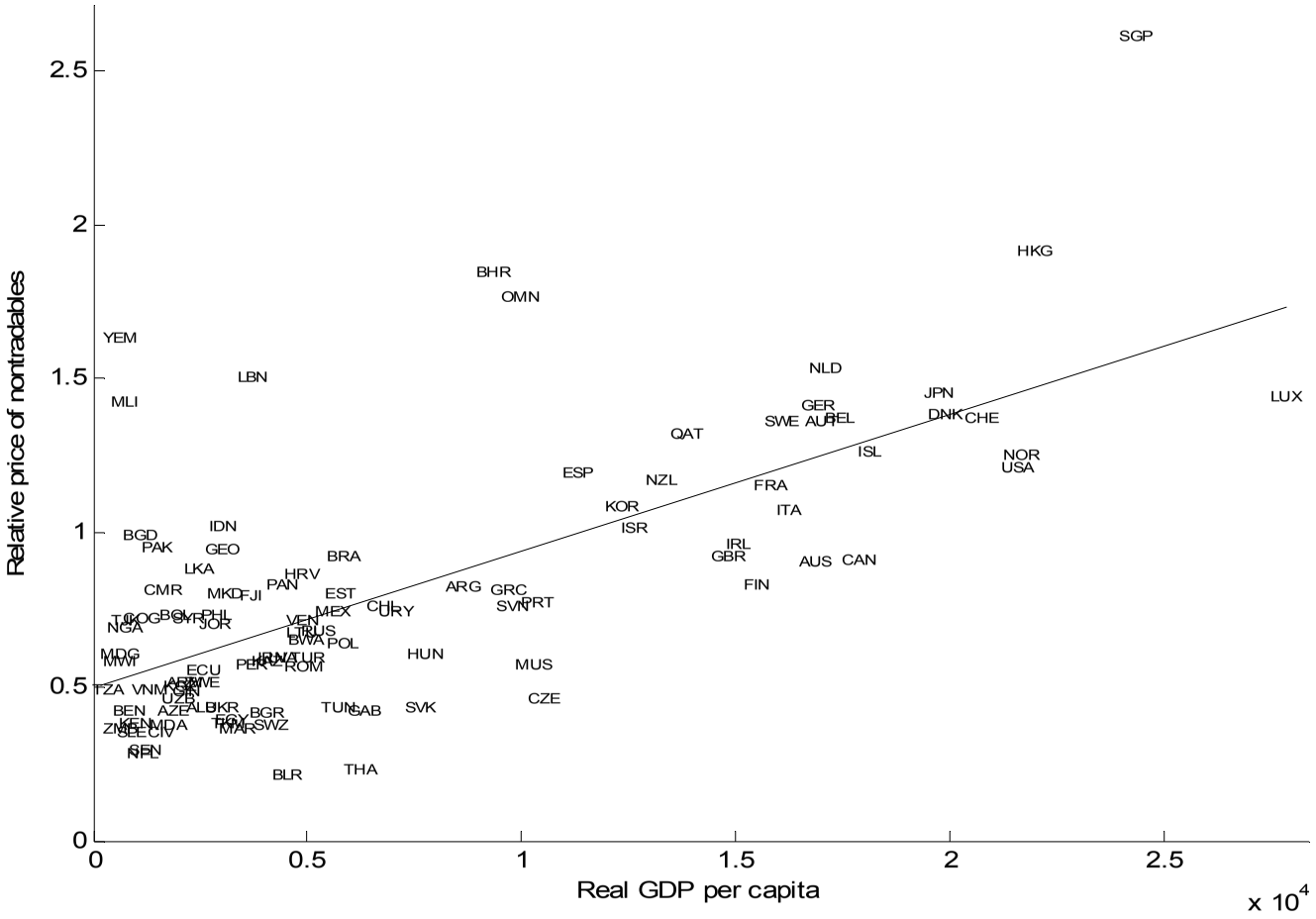
Sources: UN (2001a, b) and Heston et al. (2002).

Figure 4: Investment expenditure share on nontradables for selected regions



Source: UN (2001a, b).

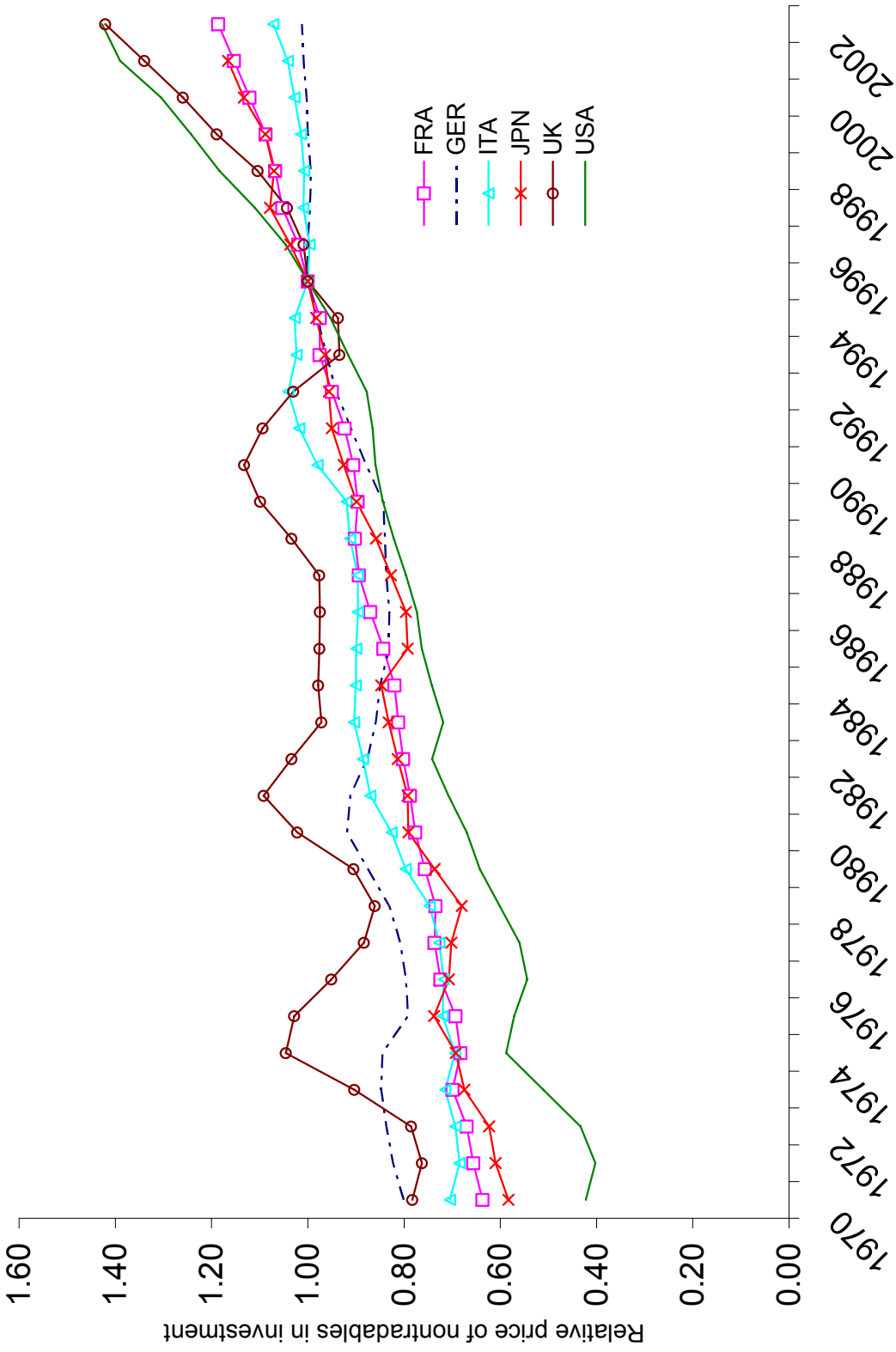
Figure 5: Relative price of nontradables in investment, 1996 PWT benchmark data /1/



Source: Heston et al. (2002).

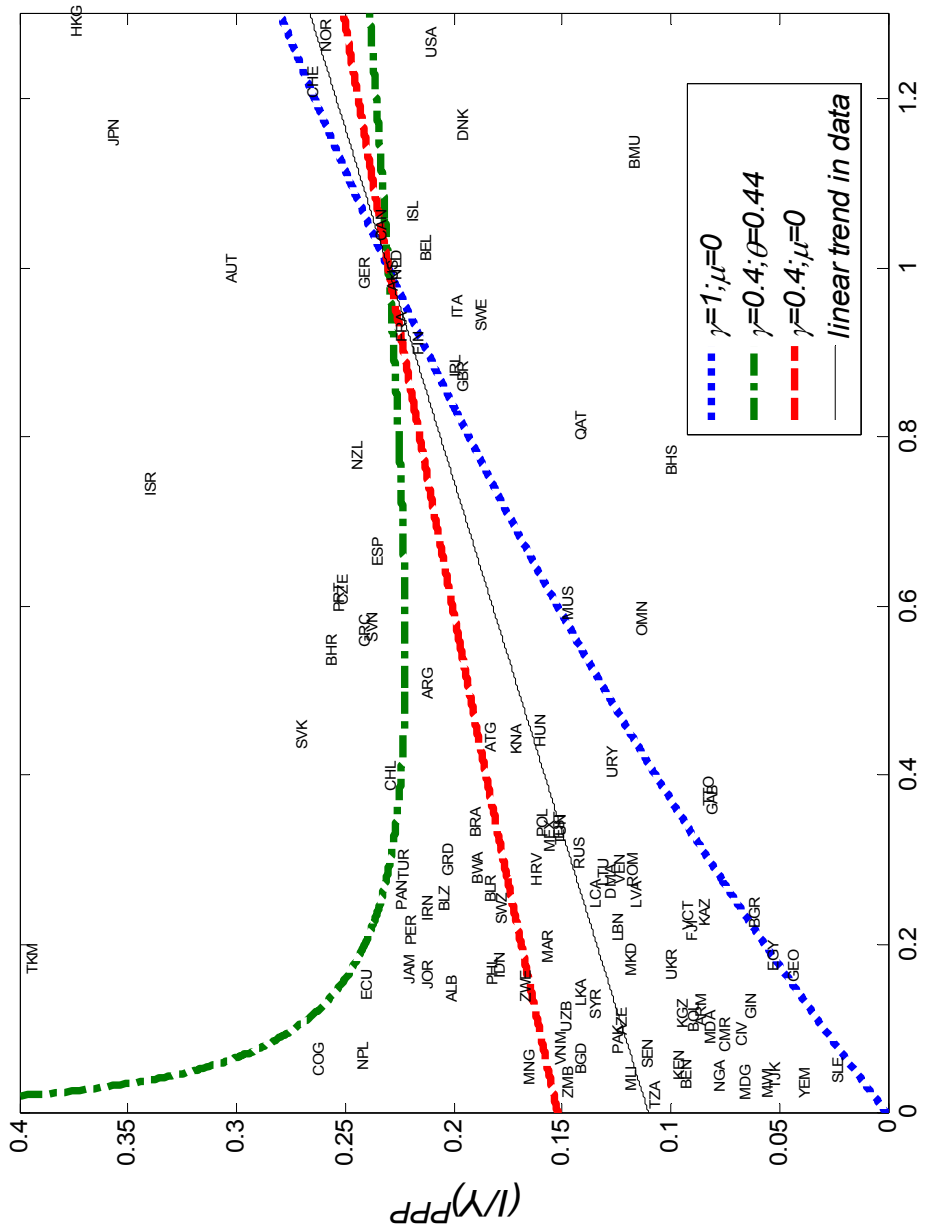
1. All sample's Caribbean islands - Antigua&Barbuda, Bahamas, Barbados, Belize, Bermuda, Dominica, Grenada, Jamaica, St. Kitts & Nevis, St. Lucia, St. Vincent&Grenadines, Trinidad&Tobago - are excluded from the figure, since **each** of these countries exhibited higher relative price than **any** other country in the sample. Average relative price for Caribbean islands is 3.74.

Figure 6: Relative price of nontradables in investment in selected countries



Source: OECD (2006).

Figure 7: Variation in investment rates under different model specifications



Source: Data from PWT 1996 benchmark, see Heston et al. (2002). X-axis: real income per capita, relative to the average for countries with at least 75% of the U.S. income. Y-axis: investment rates in international prices.