Intersectoral Implications for Construction Productivity

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Abstract

In 2020, construction accounted for 13 percent of the world's GDP following a steady growth in construction activities in the low-and-middle-income countries since the early 1990s. Furthermore, the global construction output is predicted to grow at an annual rate of 6.7 percent between 2020 and 2030. This construction boom is expected to support many low-income countries for a strong recovery from the COVID pandemic, and consequently, lower the cross-country income gap. Despite a growing interest in understanding the role of sectoral productivity gaps and intersectoral linkages in income differences across countries, the literature is mostly silent about the implications of construction for global inequality. This study examines how intersectoral linkages are associated with the spread in construction productivity across countries. Using the World Input-Output Database and multiple rounds of the International Comparisons Program data, we find the 10:1 spread in construction productivity gap between income deciles decreases by 57 percent in 2005 and 50 percent in 2011 if intersectoral linkages are modelled. A higher share of intermediate inputs to produce construction output translates into a larger increase in construction productivity in countries in the bottom five deciles compared to countries in the top five deciles, which catalyses the convergence in construction productivity across countries.

JEL: O4, O5, O11, E01, E13, L74.
Keywords: Productivity, Construction, Income convergence.

Introduction

A growing body of research documents that sectoral characterization of productivity differences can account for differences in income per capita across countries (Hsieh and Klenow 2007; Herrendorf and Valentinyi 2012; Gollin et al. 2014). One set of explanations focus on the role of specific sectors as cross-country sectoral productivity differences vary across sectors. For instance, eliminating cross-country differences in non-traditional services lowers aggregate income disparity by 58 percent, which is equivalent to an 8-fold reduction in cross-country income gaps (Duarte and Restuccia 2020). Also, low-income countries typically feature low productivity in producing investment goods (Hsieh and Klenow 2007). As such, the disparity in income can be reduced by a larger margin if productivity gaps across countries are eliminated in investment goods compared to consumption goods.

Another set of explanation highlights the role intersectoral linkages, specifically the length of the supply chain, which amplify cross-country sectoral productivity differences (Fadinger et al. 2022; McNerney et al. 2022). Thus, intersectoral linkages have direct bearings on the aggregate income effects of sectoral productivity differences. The role of intersectoral linkages on cross-country productivity in investment goods, however, is less clearly known. Since, on average, about 70 percent of construction output is used as investment goods (based on World Input-Output database, 2016), we are primarily interested in examining how intersectoral linkages affect the productivity spread in construction.

Why should one care about cross-country productivity differences in construction? Over the past three decades, construction employment and value-added share has continued to increase in 34 out of 38 low- and middle-income countries.[1] India's construction employment share (16 percent) tops the chart among a group of 51 countries, while the construction sector in China absorbs 12 percent of its employees in 2017. Furthermore, the property sector alone secures a staggering 30 percent of China's GDP in 2017 (Rogoff and Yang 2021). In 2020, construction accounted for 13 percent of the world's GDP, which is only 3 percentage points lower than the manufacturing share (McKinsey 2020). Alongside, the global construction output is predicted to grow at an annual rate of 6.7 percent between 2020 and 2030, providing a strong recovery from the COVID pandemic for low-income countries (Oxford Economics 2021). To the best of our knowledge, the sectoral and aggregate productivity implications of the growing activities in construction have not been systematically documented.

A less-productive construction sector in low-income countries can increase cross-country income gaps through a larger cross-country productivity difference in construction (direct channel), as well as a lower productivity growth in sectors that use construction as intermediate inputs or supply intermediate inputs to construction (intersectoral channel). We work with a standard multisectoral development accounting framework that captures both the direct and intersectoral implications of construction productivity. In addition, we examine how

[1] Authors' estimates based on the Economic Transformation database (GGDC-UNU-WIDER).

intersectoral linkages affect the relationship between construction and the relative price of investment across countries.[2]

We apply the World Input-Output Database (Timmer, et al. 2015) and three rounds (2005, 2011, and 2017) of the International Comparisons Program (ICP), World Bank to examine the cross-country heterogeneity in construction productivity. In the first step, we use information on sectoral expenditure and sectoral prices from the ICP database. Expenditure data produces a composite measure of sectoral productivity that reflects the input-output structure of an economy (Heston and Summers 1996), which makes the comparison of sectoral productivities across countries challenging. We instead follow Duarte and Restuccia (2020) to compute income elasticities of construction productivity from income elasticities of relative prices for construction. We find convergence in construction to GDP price ratio against that in the US across income deciles. Between 2005 and 2017, the 10:1 spread of the construction to GDP price ratio (relative to the US) across income deciles does not change, however the 10:1 spread of the GDP per capita decreases from 9.4-fold to 5.8-fold. This, in turn, helps the income elasticity of the relative construction price to go up, from 0.147 in 2005 to 0.208 in 2017.

For both the nominal expenditure share of construction and the real expenditure share of construction, the average expenditure share in construction is larger for countries in the bottom income decile (Brazil, China, India, and Indonesia) compared to the same in countries in other income deciles. The 10:1 spread of the nominal construction expenditure share across income deciles dropped from 0.712-fold in 2005 to 0.536-fold in 2017 but the change in real construction expenditure share gap between countries over time has been negligible. This is because for countries in the bottom income decile, the difference between GDP price gap (real versus nominal) and the construction price gap (real versus nominal) is larger compared to the same for countries in other income deciles.

Between 2005 and 2017, the income elasticity of construction productivity has dropped from 0.85 to 0.79. On the other hand, the 10:1 spread in the construction productivity gap becomes a factor of 6.79-fold in 2005, which drops in the subsequent years to 4.09-fold in 2011 and to 4.05-fold in 2017. In 2011 and 2017, the construction productivity gap is smaller compared to that in 2005. The convergence in cross-country construction productivity gap over time is primarily driven by a faster growth in the average construction productivity in countries in the bottom five income deciles compared to countries the top five income deciles.

We then extend our development accounting framework to incorporate input-output linkages. The magnitude of the effect of intersectoral linkages on sectoral productivity becomes smaller if the share of intermediate use in gross sectoral output is smaller, or the share of intermediate inputs from other sectors is smaller, or the share of intermediate inputs with different relative prices is smaller. Based on a sample of 40 countries that are common between

[2] One of the underlying causes of differences in the investment rate across countries is that poor countries have low productivity in producing investment goods (Hsieh and Klenow 2007).

WIOD and ICP data, we do not observe any consistent trend of the average intermediate input share that goes into producing construction output across income deciles for either benchmark year (2005, and 2011).

The average intermediate input demand (as a share of construction output) to produce construction output is relatively larger for countries in the bottom, fifth and sixth income decile. In 2005, the 10:1 spread in construction productivity gap with intersectoral linkages is lower by 57 percent (from a factor of 6.79-fold to 2.94-fold) compared to the case without I-O table in 2005. Similarly, in 2011, the 10:1 spread in construction productivity gap is lower by 50 percent (from a factor of 4.08-fold to 2.04-fold) compared to the case without I-O table in 2011. The convergence in construction productivity across countries is primarily driven by a higher share of intermediate use of construction output that translates into a larger increase in construction productivity in countries in the bottom five deciles compared to countries in the top five deciles.

As a robustness check, we compare our estimated labor productivity in construction across different models with total factor productivity (TFP) in construction available from Fadinger et al (2022). We find a much stronger correlation between construction TFP and construction labor productivity with intersectoral linkages (0.54) compared to the degree of fit between construction TFP and construction labor productivity without intersectoral linkages (0.32). This validates the implications of intersectoral linkages for construction productivity differences across countries.

Development accounting has long established that differences in aggregate total factor productivity (TFP) accounts for almost half of the cross-country income differences (Hall and Jones, 1999; Caselli 2005). More recently, sectoral development accounting highlights larger cross-country variation in productivity in certain sectors relative to the aggregate productivity variation (Herrendorf and Valentinyi 2012; Gollin et al. 2014), and amplification of cross-country sectoral TFP differences when intersectoral linkages interact with sectoral productivities (Jones 2011; Sposi 2019; Duarte and Restuccia 2020; Valentinyi 2021; Fadinger et al 2022). Despite growing evidence of activities in construction sector especially in the low-and-middle income countries, this paper is the first to account for the implications of intersectoral linkages for cross-country differences in construction productivity.

The paper is organized as follows. In section 2, we describe data sources and some stylized facts related to construction employment, value-added, prices and expenditure across countries. Section 3 starts with a baseline development accounting framework, and then presents a unified framework with intersectoral linkages, followed by a section with some concluding remarks.

2. Data and Stylized facts

2.1. Data sources

This paper uses data from three sources. First, the Economic Transformation database (GGDC / UNU-WIDER) ETD), which provides comprehensive (on value added, price deflators, and persons employed), long-term (time-series annual data from 1990 – 2018), and internationally comparable sectoral data (12 sectors) on employment and productivity in 51 economies in Africa, Asia, and Latin America. This dataset is a joint initiative of the Groningen Growth and Development Centre (GGDC) and United Nation University World Institute for Development Economics Research (UNU-WIDER) and is publicly available here: https://www.wider.unu.edu/project/etd-economic-transformation-database. We use this dataset to analyse the trends in employment and value-added in construction for the period 2000-2017.

Second, we use sectoral expenditure and prices data from three rounds (2005, 2011 and 2017) of International Comparisons Program (ICP), World Bank. The main purpose of the ICP data is to provide comparable price and volume measures of Gross Domestic Product (GDP) and its expenditure aggregates for countries. The ICP data report information on nominal expenditure (in domestic currency), and price indices for a total of individual expenditure categories. We construct nominal expenditure, real expenditure, and relative prices for constructing using the ICP data. We restrict the sample to 126 countries that have population over 1 million. Expenditure data produces a composite measure of sectoral productivity reflecting the input-output structure of an economy (Heston and Summers 1996), which makes the comparison of sectoral productivities across countries challenging. We instead follow Duarte and Restuccia (2020) to derive income elasticities of sectoral productivity from income elasticities of relative prices for each sector by incorporating an input-output structure in our multi-sector development accounting framework. We discuss this procedure in section 3.

For the baseline framework, we restrict the economy to ten sectors (agriculture, mining, manufacturing, public utility, construction, wholesale and retail trade, transport, business, public services, and private services). Since the ICP data is available for expenditure categories, we had to map them to 10 production sectors that we use in our development accounting framework. Table A1 shows the mapping between ICP expenditure categories and productions sectors. The price for agriculture is taken from the expenditure category on FOOD AND NON-ALCOHOLIC BEVERAGES (1101000). Similarly, for mining we use price from MACHINERY AND EQUIPMENT (1501100), for manufacturing price CLOTHING AND FOOTWEAR (1103000), for public utility price COLLECTIVE CONSUMPTION EXPENDITURE BY GOVERNMENT (1400000), for construction price CONSTRUCTION (1501200), for wholesale and retail trade price RESTAURANTS AND HOTELS (1111000), for transport price TRANSPORT (1107000), for business price COMMUNICATION (1108000), for public services price INDIVIDUAL CONSUMPTION EXPENDITURE BY GOVERNMENT (1300000) and lastly, for private services price INDIVIDUAL CONSUMPTION EXPENDITURE BY HOUSEHOLDS WITHOUT HOUSING (9260000).

Finally, we use the national input–output tables from the World Input-Output Database (WIOD) (see Timmer et al. 2015). These tables are available yearly, from 2000 to 2014, for 43 countries. The countries covered include EU-28 Member States (Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Germany, Denmark, Spain, Estonia, Finland, France, Greece, Hungary, Ireland, Italy, Lithuania, Luxembourg, Latvia, Malta, Netherlands, Poland, Portugal, Romania, Sweden, Slovakia, Slovenia and United Kingdom) + 15 countries (Australia, Brazil, Canada, China, Norway, India, Indonesia, Japan, Korea, Mexico, Russia, Switzerland, Taiwan, Turkey, USA) and the rest of the World. These tables use a 56 by 56 industry classification, and we aggregate them into 10 sectors to match with the price data from ICP. Table A2 presents this aggregation procedure. Combining the ICT rounds and WIOD, we obtain a sample of 40 countries that we primarily use for the empirical analysis in this paper.

2.2. Employment and Value-added Share in Construction

Panel A in Figure 1 shows how the construction employment share varies with income in 2017. India tops the chart, closely followed by Tunisia and Egypt. It is evident that the positive relationship between construction employment share and income level is primarily driven by the middle-income countries, which on average hire almost twice the size of the proportion of employees in construction compared to the low-income and the high-income countries. Panel B shows the change in the employment share in construction between 2000 and 2017. The share of employment in construction increased, on average, for the low- and the middle-income countries, at a higher rate compared to the high-income countries.

The panel C of Figure 1 plots the value-added share in construction and GDP per capita. We do not find much difference in the average value-added share in construction across the low-and-middle-income and the high-income countries. In some of the low-income countries (Ethiopia, Tanzania, Zambia, among others), the value-added share in construction is larger compared to the rest of the countries, which makes the slope of the linear fit between the value-added in construction and income look slightly negative. The change in the value-added share in construction is, on average, larger in the low-and-middle-income countries relative to the high-income countries (Panel D). Overall, both in terms of employment and value-added, we find evidence supporting growing activities in construction especially among the low-and-middle-income countries.

2.3. Relative Prices in Construction

The price ratio of construction to GDP increases with GDP per capita, and we observe this pattern remain unchanged across 2005, 2011 and 2017 (Figure 2). The income elasticity of the construction price (relative to GDP) is estimated as 0.147 in 2005, 0.173 in 2011, which has further increased to 0.208 in 2017 (Table 1). While the slope of the fitted line between relative price in construction and income got steeper over time, the size of the intercept has dropped between 2005 and 2011, and even to a smaller size between 2011 and 2017. A larger decline in the average relative price in construction for the low-and -middle-income countries compared to the high income-countries between 2005 and 2017 could possibly explain the gradual decrease in the size of the intercept.

To get a closer picture of how the level of income (relative to the US) and the price ratio of construction to GDP (relative to the US) changes across income deciles of countries, and over time, we next plot the average ratio between real GDP per capita and real GDP per capita in the US across income deciles. The relative income has gradually increased from 2005 to 2011, and from 2011 to 2017 in almost each income decile. The margin of the change has been slightly higher for countries in the bottom three income deciles compared to countries in the top three income deciles. On the other, we find convergence in the construction to GDP price ratio (relative to that in the US) across income deciles (panel B). Between 2005 and 2017, the drop in the construction-GDP price ratio (relative to that in the US) has been larger for the countries in the bottom four income deciles compared to the countries in the top four income deciles. Figure 2 and Figure 3 suggest convergence in construction productivity across this group of 40 countries between 2005 and 2017.

2.4. Construction Shares of GDP

We next compare the ratio of expenditure in construction to total expenditure (GDP) in domestic prices (the top panel, Figure 4). China shows the largest expenditure share in consumption (about 30 percent), followed by Indonesia (around 24 percent). The relationship between the nominal construction share of GDP and GDP per capita remains negative across the three benchmark years: 2005, 2011, and 2017. We find similar negative relationship between the real construction share of GDP and GDP per capita (the bottom panel, Figure 4). Once measured in PPP prices, the share of total expenditure in construction systematically increases. This implies that across the board the gap between domestic price of GDP and PPP-adjusted price of GDP is smaller compared to the gap between domestic price of construction and PPP-adjusted price of construction. For some countries (e.g., China and Indonesia) the gap between the nominal and the real construction expenditure share is larger compared to other countries (e.g., India and Turkey).

Figure 5 plots the average nominal expenditure share of construction (panel A) and the average real expenditure share of construction (panel B) by income decile. In both cases, the average expenditure share in construction is larger for countries in the bottom income decile (Brazil, China, India, and Indonesia) compared to the same in countries in other income deciles. However, the gap between the average expenditure share in the bottom income decile and the average expenditure share in other income deciles is lower in the real terms compared to the nominal terms. This is because for countries in the bottom income decile, the difference between GDP price gap (real versus nominal) and the construction price gap (real versus nominal) is larger compared to the same for countries in other income deciles.

We also note that the real value-added share of construction (Figure 1, panel C) and the real expenditure share of construction (Figure 4, panel B) vary with income differently. As income increases, the real expenditure share of construction decreases much faster than the real value-added share of construction. Even though the total expenditure and total value-added equal the GDP of a country, expenditure data reflects the input-output structure of an economy and thus creates a wedge between the sectoral share of value-added and the sectoral share of expenditure (Heston and Summers 1996). In addition, measurement issues also partly explain this discrepancy. For Figure 1, we use a larger sample of 51 countries and ETD data, whereas Figure 4 is drawn using ICT data and a sample of 40 countries.

To conclude, we find strong evidence for growing activities in construction over time in the low-income countries. At the same time, as summarized in Table 1, the 10:1 spread of the ratio between construction to GDP price (relative to the US) does not change much over time whereas the 10:1 spread of the GDP per capita significantly drops between 2005 and 2017. As a result of which, the income elasticity increases from 0.147 in 2005 to 0.208 in 2017. On the other hand, the 10:1 spread of the nominal constructure expenditure share across income deciles dropped from 0.712-fold in 2005 to 0.536-fold in 2017. The change in the 10:1 spread of the real construction expenditure share across income deciles has been negligible during the same period of time.

The cross-country heterogeneity in relative prices in construction change between 2005 and 2017. We find the 10:1 spread in the construction to GDP price ratio (relative to that in the US) between income deciles 1.53-fold in 2005, 1.60-fold in 2011, and 1.57-fold in 2017. Relative price differences implicate differences in construction productivity across countries following Baumol's cost disease mechanism (Baumol 1967). However, cross-country sectoral productivity differences can also be associated with other factors, such as industry-specific characteristics, variation in the intensity of sectoral trade, product market competition and the length of the supply chain (McNerney et al. 2022). We rely on differences in relative prices to explain the cross-country differences in construction productivity following Duarte and Restuccia (2020). We take this discussion forward in section 3.

3. Development Accounting Framework

3.1. Baseline model

We begin with a simple development accounting framework following Herrendorf and Valentinyi (2012) and Duarte and Restuccia (2020). Output in sector i (Y_i) is produced with labor (L_i) following linear technologies, $Y_i = A_i L_i$, where A_i is labor productivity in sector i. In addition to linear technologies in labor, we assume competitive markets for good and labor, and free movement of labor between sectors. Consider P_i is the price of output in sector i , and w is the common wage rate across sectors. The profit-maximizing conditions can be derived from the first-order conditions for all i as

$$p_i A_i = w. \quad (1)$$

The value of aggregate output in domestic prices can be written as $\sum_i p_i A_i = wL$, where $\sum_i L_i = L$. The nominal wage rate in this simple model is nothing but the per capita aggregate output in nominal price. Denoting the nominal price of GDP as p, we divide both sides of equation (1) by p and take log. Rearranging the terms, we obtain an expression for sectoral productivity, as follows:

$$log(A_i) = log(GDPpc) - log(\frac{P_i}{P}). \quad (2)$$

Differentiating equation (2) with respect to $log(GDPpc)$, the relationship between income elasticity of sectoral productivity (A_i) and income elasticity of sectoral relative price $(\frac{P_i}{P})$ becomes:

$$\frac{dlog(A_i)}{dlog(GDPpc)} = 1 - \frac{dlog(\frac{P_i}{P})}{dlog(GDPpc)}. \quad (3)$$

Using Equation (3), and the summary statistics presented in Table 1, a 1% higher GDP per capita leads to 0.85% $[= 1 - 0.147]$ higher productivity in construction in 2005, 0.83% $[= 1 - 0.173]$ higher productivity in construction in 2011, and 0.79% $[= 1 - 0.208]$ higher productivity in construction in 2017. Between 2005 and 2017, the income elasticity of construction productivity has dropped from 0.85 to 0.79. On the other hand, the 10:1 spread in the construction productivity gap becomes a factor of 6.79 $[= \exp[0.85 \times \log(9.445)]$ fold in 2005, which drops in the subsequent years to 4.09 $[= \exp[0.83 \times \log(5.492)]$ fold in 2011 and to 4.05 $[= \exp[0.79 \times \log(5.849)]$ fold in 2017. In 2011 and 2017, the construction productivity gap is smaller compared to that in 2005. The convergence in cross-country construction productivity gap over time is primarily driven by a faster growth in the average construction productivity for countries in the bottom five income deciles relative to the top five income deciles.

3.2. Baseline model Extension (A Larger Sample of Countries)

To gain further insights on cross-country differences in construction productivity, we consider a much larger sample of 126 countries available from the ICP rounds. As Table A3 reports, the size of the income elasticity of the construction productivity goes up as the number of countries increase from 40 to 126. We find a 1% higher GDP per capita associated with 0.98% $[= 1 - 0.016]$ higher productivity in construction in 2005, 0.95% $[= 1 - 0.045]$ higher productivity in construction in 2011, and 1.01% $[= 1 - (-1.009)]$ higher productivity in construction in 2017. The 10:1 spread in the construction productivity gap becomes a factor of

54.2 $[= \exp[0.98 \times \log(57.864)]$ fold in 2005, 40.7 $[= \exp[0.95 \times \log(48.435)]$ fold in 2011, and 45.6 $[= \exp[1.01 \times \log(44.003)]$ fold in 2017. Hence, the 10:1 spread in construction productivity gap increases by almost 8 times in 2005, more than 10 times in 2011 and 2017 as the sample size of countries increases from 40 to 126. Since only 40 countries are common between WIOD and ICP, we could not use this bigger sample of 126 countries to evaluate the implications of intersectoral linkages on construction productivity.

3.3. Model with Intersectoral Linkages

Following Duarte and Restuccia (2020), we incorporate input-output structure in our development accounting framework developed in section 3.1. The gross output production function becomes $Q_i = B_i {L_i}^{1-\alpha_i} {H_i}^{\alpha_i}$, where B_i is productivity level of gross output in sector i, α_i is the share of produced inputs in each sector. H_i is the composite of intermediate inputs: $H_i = \prod_j \left(\frac{h_{ji}}{\emptyset_{ji}}\right)^{\emptyset_{ji}}$, where h_{ji} is the quantity of intermediate input j used to produce output in sector i, and $\emptyset_{ji}$ is the share of total input j in total intermediate input use. Solving for the profit maximization of sectoral output, produces an expression for sectoral productivity (Please see Duarte and Restuccia (2020) for derivation of this expression)

$$log(A_i) = log(GDPpc) - log\left(\frac{P_i}{P}\right) - \frac{\alpha_i}{1-\alpha_i} \sum_j \emptyset_{ji} \left[log\left(\frac{P_i}{P}\right) - log\left(\frac{P_j}{P}\right)\right] \quad (4)$$

Equation (4) suggests that the magnitude of the effect of intersectoral linkages on sectoral productivity construction becomes smaller if the share of intermediate inputs in gross output is smaller, or the share of intermediate inputs from other sectors is smaller, or the share of intermediate inputs with different relative prices is smaller. Thus, in the development accounting framework with intersectoral linkages, quantitative implications of intersectoral network depends largely on the values of α_i and $\emptyset_{ji}$.

We use data from the World Input-output Database (Timmer, et al., 2015), which includes national input-output (I-O) tables for 43 countries for the period: 2000-2014 in a 56 by 56 industry classification. We aggregate the I-O tables for 10 sectors (AGR, MIN, MAN, PU, CON, TRA, WRT, BUS, PUBS, and PRIS), and compute the parameters (α_i and $\emptyset_{ji}$) using a 10 by 10 I-O table format (See Table A2). Since WIOD is avalaible for only for the period from 2000 to 2014, the analysis in this discussion is feasible only for two benchmark years: 2005 and 2011. Figure 6 compares the average interemdiate input share of construction across income deciles of countries. We do not find any consistent pattern for the average intermediate input share of construction across income deciles. The average intermediate input share of construrtcion output is relatively higher for countries in the bottom, fifth and sixth income decile. The average intermediate input demand (as a share of construction output) to produce construction output for countries in the bottom income decile increases from 0.54 in 2005 to 0.56 in 2011, where it decreases for countries in other income deciles.

Table 2 compares the outcomes on cross-country construction productivity differences between the baseline model (without intersectoral linkages) and the one with intersectoral linkages. Based on the development accounting framework with intersectoral linkages, a 1% higher GDP per capita is associated with a 0.48% higher productivity in construction in 2005 compared to 0.85% in 2005 using the baseline model, and a 0.42% higher productivity in construction in 2011 compared to 0.83% in 2011 using the baseline model. With intersectoral linkages, the 10:1 spread in construction productivity gap reduces to a factor of 2.94-fold in 2005 compared to a factor of 6.79-fold using the baseline model in 2005. Similarly, with intersectoral linkages the 10:1 spread in construction productivity gap reduces to a factor of 2.04-fold in 2011 compared to a factor of 4.08-fold using the baseline model 2011.

To understand whether intersectoral linkages have any heterogenous effect on construction productivity across countries in different income deciles, we compare the average construction productivity from the baseline model and the alternative model with intersectoral linkages by income deciles. Panel A of Figure 7 presents the outcomes for 2005. In the presence of intersectoral linkages, countries in the bottom five deciles show a larger gain in the average construction productivity compared to countries in the top five income deciles. The average construction productivity increases by almost three-fold for countries in the bottom decile in 2005. We find similar evidence for 2011 (panel B). The role of intersectoral linkages in enhancing construction productivity is more prominent for countries in lower income deciles. As a result, for both benchmark years, disparity in construction productivity lowers due to intersectoral linkages. The 10:1 spread in construction productivity gap across income deciles declines by 57 percent in 2005, and 50 percent in 2011 if intersectoral linkages are modelled. This effect is largely driven by a substantial (two-to-three-fold) increase in the average construction productivity for countries in the bottom income decile (Figure 7).

Furthermore, a larger productivity gain in construction is also strongly correlated with a higher share of intermediate use of construction output for countries in the bottom income decile. Presumably, the low-and-middle-income countries, on average, require more construction inputs for production in other sectors compared to high-income countries as more buildings, roads, and other infrastructural support are needed owing to their underdeveloped stage. The demand for construction inputs gradually diminishes as the level of income rises.

Sectoral productivity in our development accounting framework is measured as labor productivity, which could be driven by factors other than intersectoral linkages. The change in labor productivity due to intersectoral linkages is robust only when similar change is observed in other measures of productivity, such as total factor productivity (TFP). As a robustness check, we compare our construction productivity estimates with the construction TFP from Fadinger et al (2022). The authors compute PPP-adjusted TFP for 35 sectors comparable across 38 countries using the WIOD data, which satisfy a set of basic requirements for TFP comparisons across countries[3]. We find a much stronger correlation between construction TFP and construction labor productivity with intersectoral linkages of 0.54 compared to the degree of fit between construction TFP and construction labor productivity without intersectoral linkages (0.32).

5. Conclusion

Construction sector provides inputs to almost all sectors in the economy, and on average, the intermediate input demand to produce construction output is higher for the low-income countries compared to the high-income countries. As longer supply chain makes a sector more productive, we also find evidence for a higher construction productivity in low-income countries compared to high-income countries. This in turn lowers the disparity in construction productivity across countries.

Due to availability of input-output for a select few countries, our analysis examining the role of intersectoral linkages on construction productivity gap across countries is limited to a sample of 40 countries. Evidence from ICP data suggest that the 10:1 spread in construction productivity across income deciles increases by almost 8 to 10 times as the sample of countries increases from 40 to 126, however without intersectoral linkages. This evidence is particularly encouraging and can lead to a new field of research with the availability of novel input-output datasets especially for the low-income countries.

Finally, this paper serves as a crucial step to understand how elimination of construction productivity gap changes income disparity across countries. We leave this task for a future paper.

[3] See Fadinger et al (2022), page 379, for further details.

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Table 1. Development Accounting: Relative Prices and Expenditure Shares

		Real GDP Per Capita	Relative Construction Price (Rel to the US)	Real Construction Expenditure Share	Nominal Construction Expenditure Share
Decile 10 / Decile 1	2005	9.445	1.528	0.420	0.712
	2011	5.492	1.597	0.328	0.508
	2017	5.849	1.566	0.358	0.536
Income Elasticity	2005		0.147	-0.272	-0.125
			(0.039)	(0.079)	(0.062)
	2011		0.173	-0.494	-0.321
			(0.054)	(0.087)	(0.078)
	2017		0.208	-0.438	-0.229
			(0.060)	(0.107)	(0.106)

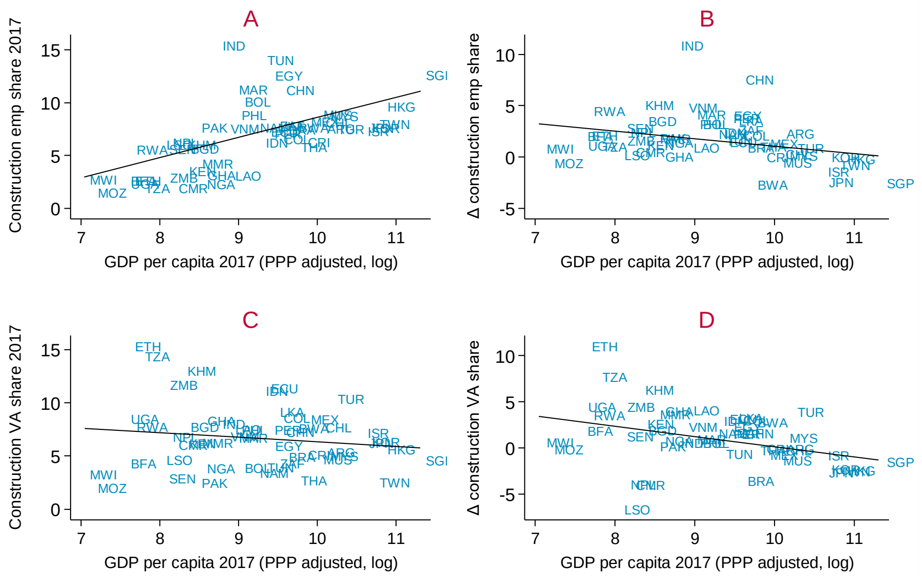
Source: Authors' estimates based on data from 2005, 2011, and 2017 rounds of the International Comparisons Program (ICP), World Bank.
Note: The sample includes 40 countries with population size of more than a million, and that are common between ICP and World Input-Output data (WIOD). Countries are ranked according to real GDP per capita and distributed among 10 income declines. Income elasticity is measured as the slope coefficient of an OLS regression of the log of each variable on log real GDP per capita across 40 countries in the sample. Standard errors are in parenthesis.

Table 2. Development Accounting: Construction Productivity with and without I-O Table

		Real GDP Per Capita	Intermediate input share in construction output	Construction productivity (without I-O table)	Construction Productivity (with I-O table)
Decile 10 / Decile 1	2005	9.445	0.816	6.791	2.941
	2011	5.492	0.807	4.089	2.046
Income Elasticity	2005			0.853	0.480
				(0.039)	(0.103)
	2011			0.827	0.420
				(0.054)	(0.117)

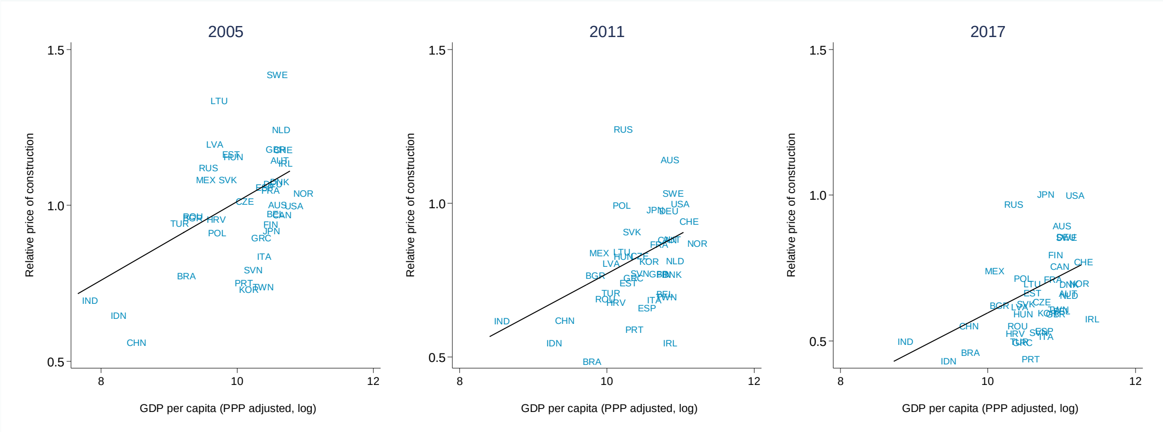
Source: Authors' estimates based on data from the World Input-output Database (Timmer, et al., 2015) and data from 2005 and 2011 rounds of the International Comparisons Program (ICP), World Bank.
Note: The sample includes 40 countries with population size of more than a million, and that are common between ICP and World Input-Output data (WIOD). Countries are ranked according to real GDP per capita and distributed among 10 income declines. Construction productivity without I-O table is calculated based on equation (1), and construction productivity with I-O table is calculated based on equation (3) with 10 sectors.

Figure 1. Construction Employment and Value-added Share, 2000-2017



Source: Authors' estimates based on the Economic Transformation database (GGDC-UNU-WIDER).
Note: Graphs include 56 countries. The change in the construction employment (Value-added) share is the percentage points change in construction (vaue-added)

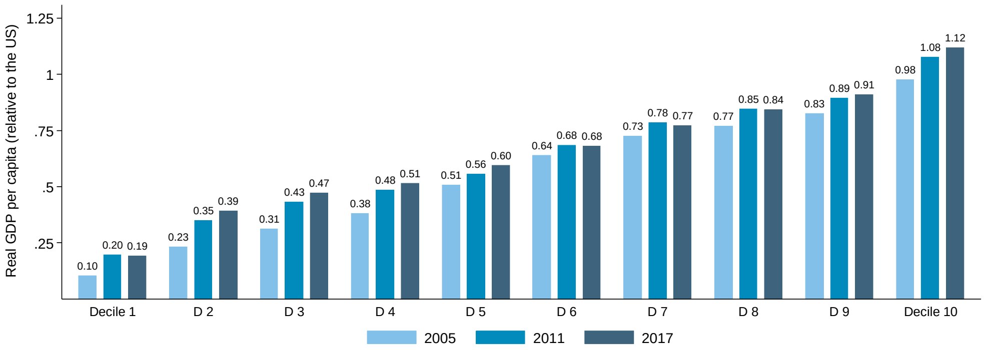
Figure 2. Relative Price of Construction and GDP Per Capita: 2005, 2011, and 2017



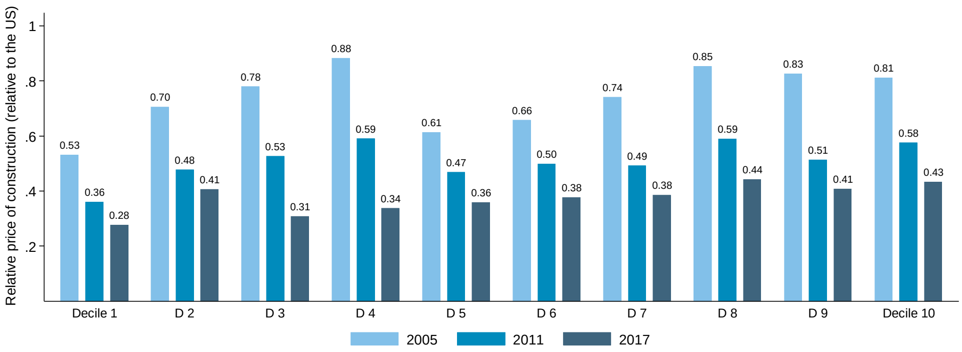
Source: Authors' estimates based on data from 2005, 2011, and 2017 rounds of the International Comparisons Program (ICP), World Bank.
Note: The sample includes 40 countries with population size of more than a million, and that are common between ICP and World Input-Output data (WIOD). Relative price of construction = PPP price of construction relative to PPP price of GDP.

Figure 3. Real GDP Per Capita and Construction Price by Income Decile: 2005, 2011, and 2017

A. Real GDP Per Capita (Relative to the US) by Income Decile



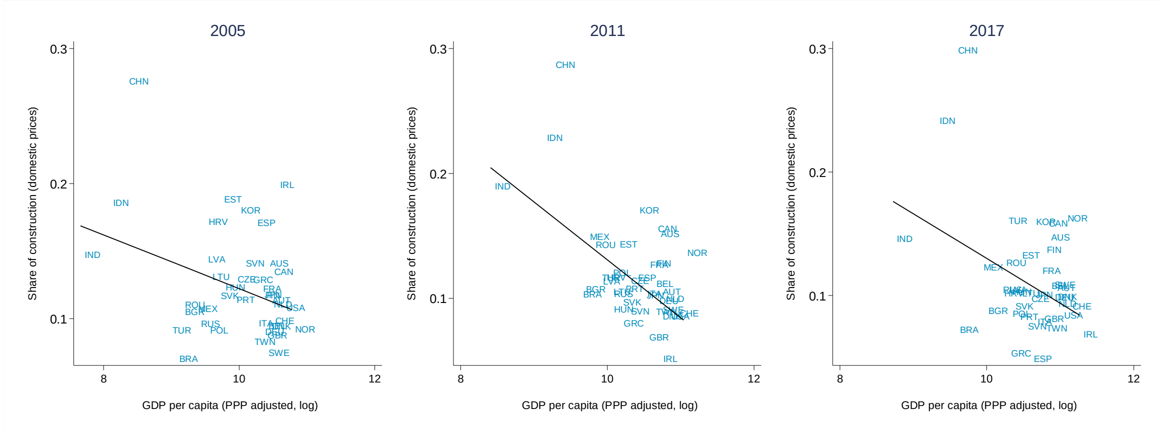
B. Relative Construction Price (Relative to the US) by Income Decile



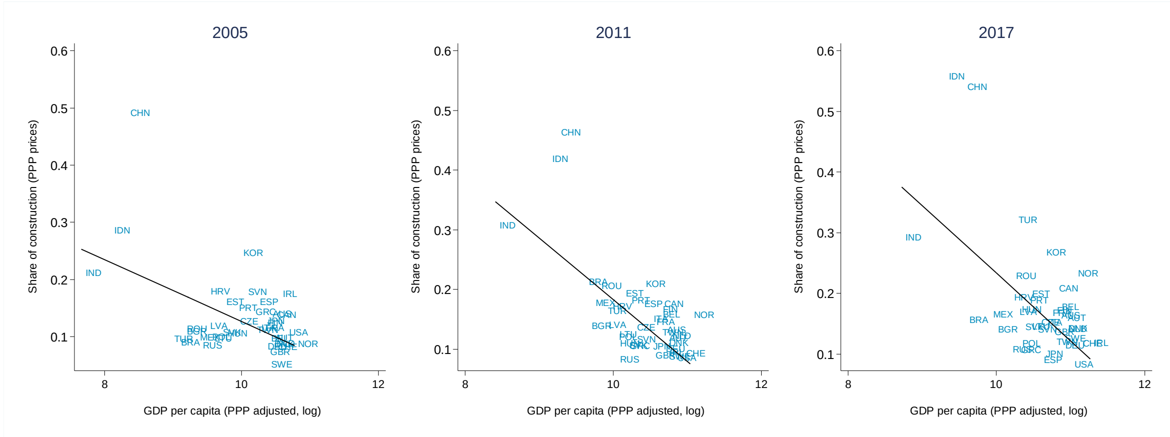
Source: Authors' estimates based on data from 2005, 2011, and 2017 rounds of the International Comparisons Program (ICP), World Bank.
Note: The sample includes 40 countries with population size of more than a million, and that are common between ICP and World Input-Output data (WIOD). Countries are ranked according to real GDP per capita and distributed among 10 income deciles. Real GDP per capita (relative to the US) = Real GDP per capita relative to real GDP per capita in the US. Relative price of construction (relative to the US) = Relative price of construction relative to price of GDP (both PPP adjusted) relative to that in the US.

Figure 4. Construction Share of GDP and GDP Per Capita: 2005, 2011, and 2017

A. Construction Share (Domestic Prices) and GDP Per Capita



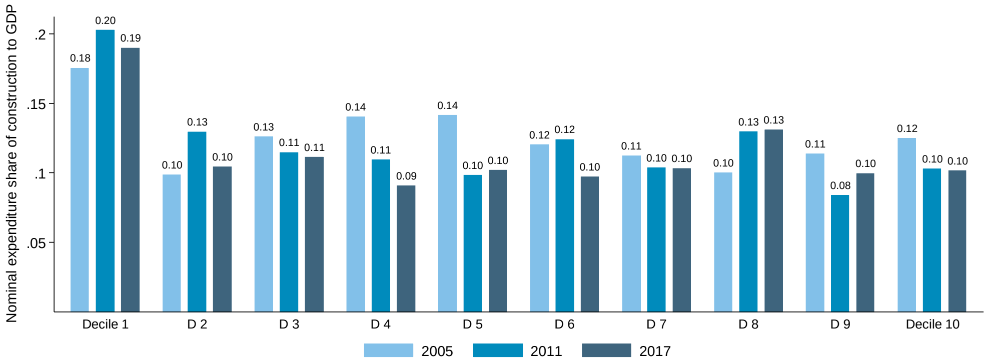
B. Construction Share (PPP prices) and GDP Per Capita



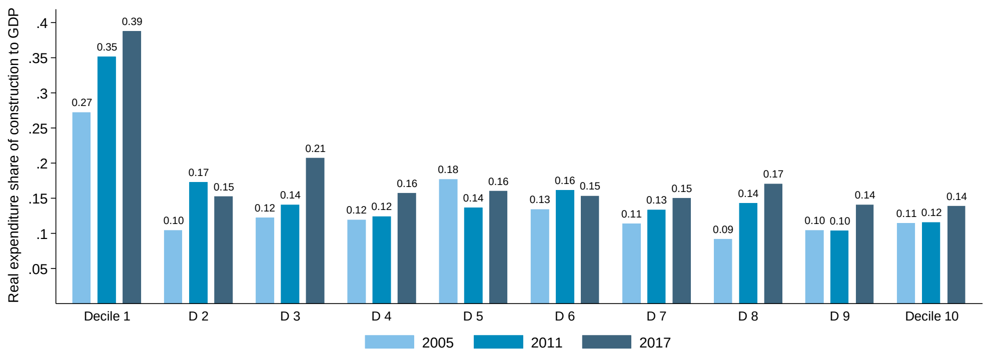
Source: Authors' estimates based on data from 2005, 2011, and 2017 rounds of the International Comparisons Program (ICP), World Bank.
Note: The sample includes 40 countries with population size of more than a million, and that are common between ICP and World Input-Output data (WIOD). Share of construction (domestic price) = nominal expenditures in construction relative to nominal GDP. Share of construction (PPP prices) = Expenditures in construction in PPP-adjusted prices relative to GDP in PPP-adjusted prices.

Figure 5. Consumption Expenditure in Construction by Income Decile: 2005, 2011, and 2017

A. Nominal expenditure share



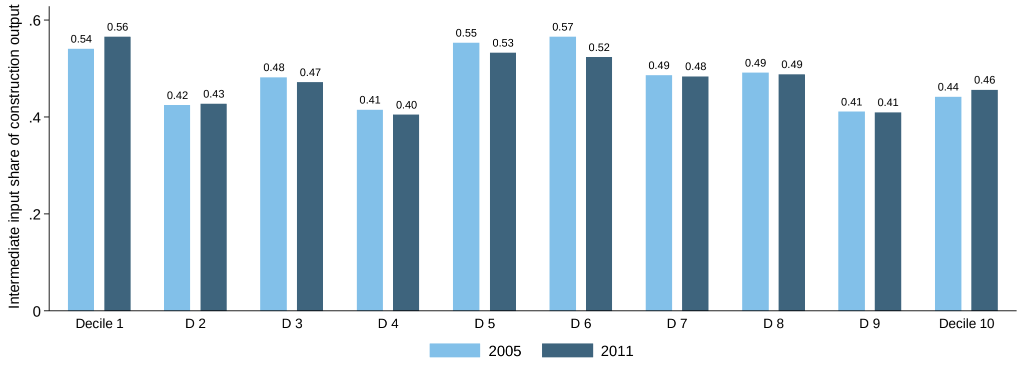
b. Real expenditure share



Source: Authors’ estimates based on data from 2005, 2011, and 2017 rounds of the International Comparisons Program (ICP), World Bank.

Note: The sample includes 40 countries with population size of more than a million, and that are common between ICP and World Input-Output data (WIOD). Countries are ranked according to real GDP per capita and distributed among 10 income declines. Real expenditure share of construction to GDP = Construction expenditure (PPP-adjusted prices) relative to GDP in PPP-adjusted prices. Nominal expenditure share of construction to GDP = Construction expenditure in domestic prices relative to GDP in domestic prices.

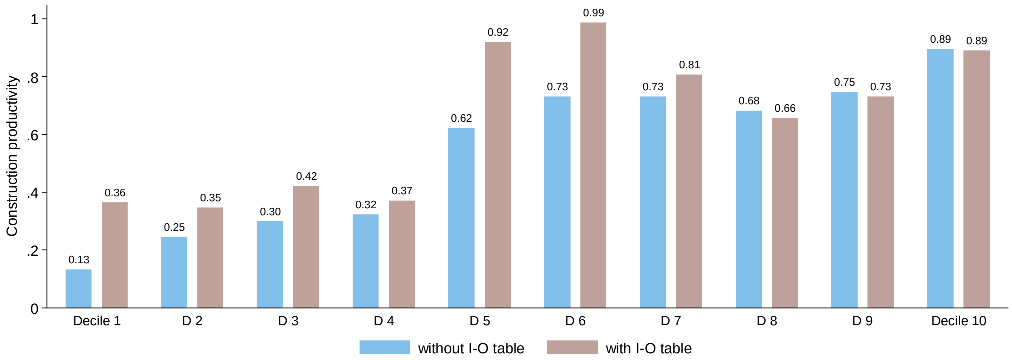
Figure 6. Intermediate Input Share of Construction Output



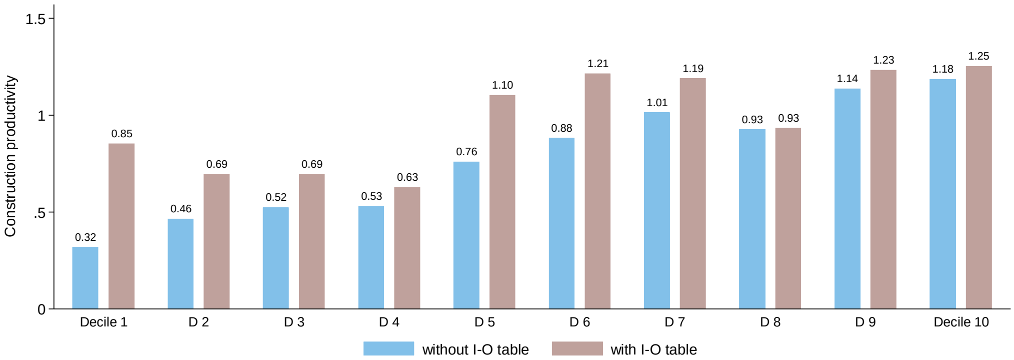
Source: Authors' estimates based on data from the World Input-output Database (Timmer, et al., 2015).
Note: The sample includes 40 countries with population size of more than a million, and that are common between ICP and World Input-Output data (WIOD). Countries are ranked according to real GDP per capita and distributed among 10 income declines. Intermediate input share of construction output = the share of produced inputs in construction output.

Figure 7. Construction Productivity, With and Without Intersectoral Linkages

A. 2005

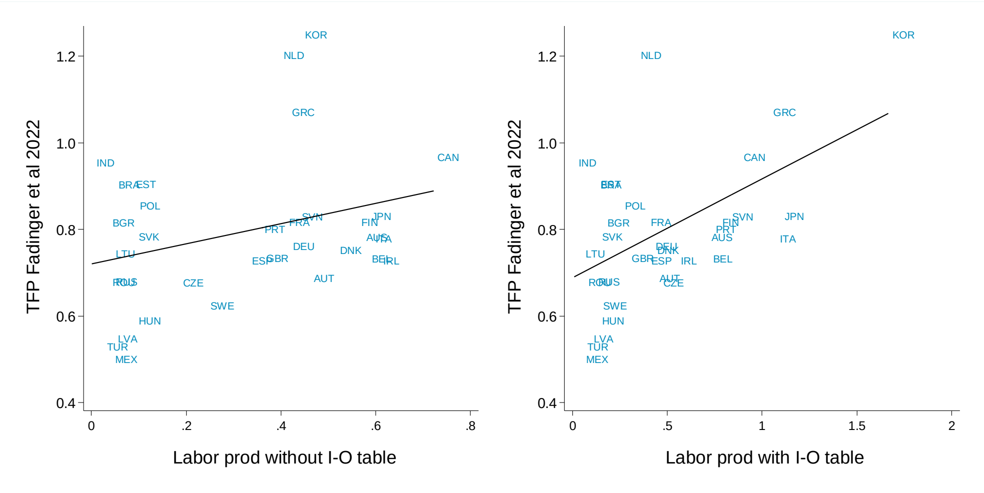


B. 2011



Source: Authors' estimates based on data from the World Input-output Database (Timmer, et al., 2015) and data from 2011 round of the International Comparisons Program (ICP), World Bank.
Note: The sample includes 40 countries with population size of more than a million, and that are common between ICP and World Input-Output data (WIOD). Countries are ranked according to real GDP per capita and distributed among 10 income declines. Construction productivity without I-O table is calculated based on equation (1), and construction productivity with I-O table is calculated based on equation (3) with 10 sectors.

Figure 8. Robustness check with Construction TFP from Fadinger et al (2022)



Source: Authors' estimates based on data from the World Input-output Database (Timmer, et al., 2015) and data from 2005 round of the International Comparisons Program (ICP), World Bank and estimates from Fadinger et al (2022).
Note: The sample includes 33 countries that are common between ICP, World Input-Output data (WIOD) and Finger et al (2022). Construction labor productivity without I-O table is calculated based on equation (1), and construction labor productivity with I-O table is calculated based on equation (3) with 10 sectors. Construction TFP is taken form Faidinger et al (2022).

Appendix Tables and Figures

Table A1. Mapping of Production Sectors and Expenditure Categories

	Production sectors	ICP expenditure categories
1	Agriculture	FOOD AND NON-ALCOHOLIC BEVERAGES (1101000)
2	Mining	MACHINERY AND EQUIPMENT (1501100)
3	Manufacturing	CLOTHING AND FOOTWEAR (1103000)
4	Public utility	COLLECTIVE CONSUMPTION EXPENDITURE BY GOVERNMENT (1400000)
5	Construction	CONSTRUCTION (1501200)
6	Wholesale and retail trade	RESTAURANTS AND HOTELS (1111000)
7	Transport	TRANSPORT (1107000)
8	Business	COMMUNICATION (1108000)
9	Public services	INDIVIDUAL CONSUMPTION EXPENDITURE BY GOVERNMENT (1300000)
10	Private services	INDIVIDUAL CONSUMPTION EXPENDITURE BY HOUSEHOLDS WITHOUT HOUSING (9260000)

Source: Authors' estimates based on data from the World Input-output Database (Timmer, et al., 2015) and data from 2005, 2011, and 2017 rounds of the International Comparisons Program (ICP), World Bank.

Table A2. Mapping of WIOD sectors to 10-sector categories

	WIOD sectors		10-sector category
1	Crop and animal production, hunting and related service activities	**c1**	Agriculture
2	Forestry and logging	**c2**	
3	Fishing and aquaculture	**c3**	
4	Mining and quarrying	**c4**	Mining
5	Manufacture of food products, beverages and tobacco products	**c5**	Manufacturing
6	Manufacture of textiles, wearing apparel and leather products	**c6**	
7	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	**c7**	
8	Manufacture of paper and paper products	**c8**	
9	Printing and reproduction of recorded media	**c9**	
10	Manufacture of coke and refined petroleum products	**c10**	
11	Manufacture of chemicals and chemical products	**c11**	
12	Manufacture of basic pharmaceutical products and pharmaceutical preparations	**c12**	
13	Manufacture of rubber and plastic products	**c13**	
14	Manufacture of other non-metallic mineral products	**c14**	
15	Manufacture of basic metals	**c15**	
16	Manufacture of fabricated metal products, except machinery and equipment	**c16**	
17	Manufacture of computer, electronic and optical products	**c17**	
18	Manufacture of electrical equipment	**c18**	
19	Manufacture of machinery and equipment n.e.c.	**c19**	
20	Manufacture of motor vehicles, trailers and semi-trailers	**c20**	
21	Manufacture of other transport equipment	**c21**	
22	Manufacture of furniture; other manufacturing	**c22**	
23	Repair and installation of machinery and equipment	**c23**	
24	Electricity, gas, steam and air conditioning supply	**c24**	Public utility
25	Water collection, treatment and supply	**c25**	
26	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services	**c26**	
27	Construction	**c27**	Construction
28	Wholesale and retail trade and repair of motor vehicles and motorcycles	**c28**	Wholesale and retail trade
29	Wholesale trade, except of motor vehicles and motorcycles	**c29**	
30	Retail trade, except of motor vehicles and motorcycles	**c30**	
31	Land transport and transport via pipelines	**c31**	Transport
32	Water transport	**c32**	
33	Air transport	**c33**	
34	Warehousing and support activities for transportation	**c34**	
35	Postal and courier activities	**c35**	
36	Accommodation and food service activities	**c36**	Business
37	Publishing activities	**c37**	
38	Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities	**c38**	
39	Telecommunications	**c39**	
40	Computer programming, consultancy and related activities; information service activities	**c40**	
41	Financial service activities, except insurance and pension funding	**c41**	
42	Insurance, reinsurance and pension funding, except compulsory social security	**c42**	
43	Activities auxiliary to financial services and insurance activities	**c43**	
44	Real estate activities	**c44**	
45	Legal and accounting activities; activities of head offices; management consultancy activities	**c45**	
46	Architectural and engineering activities; technical testing and analysis	**c46**	
47	Scientific research and development	**c47**	
48	Advertising and market research	**c48**	
49	Other professional, scientific and technical activities; veterinary activities	**c49**	
50	Administrative and support service activities	**c50**	
51	Public administration and defence; compulsory social security	**c51**	Public services
52	Education	**c52**	
53	Human health and social work activities	**c53**	Private services
54	Other service activities	**c54**	
55	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	**c55**	
56	Activities of extraterritorial organizations and bodies	**c56**	

Source: Authors' estimates based on data from the World Input-output Database (Timmer, et al., 2015) and data from 2005, 2011, and 2017 rounds of the International Comparisons Program (ICP), World Bank

Table A3. Development Accounting Outcomes Based on 126 Countries

		Real GDP Per Capita (Rel to the US)	Relative Construction Price (Rel to the US)	Real Construction Expenditure Share	Nominal Construction Expenditure Share
Decile 10 / Decile 1	2005	57.864	0.988	1.151	1.174
	2011	48.435	1.150	0.657	0.758
	2017	44.003	1.067	0.821	0.907
Income Elasticity	2005		0.016	0.016	0.044
			(0.023)	(0.039)	(0.032)
	2011		0.045	-0.048	-0.004
			(0.024)	(0.037)	(0.029)
	2017		-0.009	0.015	0.005
			(0.018)	(0.038)	(0.034)

Source: Authors' estimates based on data from 2005, 2011, and 2017 rounds of the International Comparisons Program (ICP), World Bank.
Note: The sample includes 126 countries with population size of more than a million. Countries are ranked according to real GDP per capita and distributed among 10 income declines. Income elasticity is measured as the slope coefficient of an OLS regression of the log of each variable on log real GDP per capita across 126 countries in the sample. Standard errors are in parenthesis.