The Quantitative Role of Capital-Goods Imports in U.S. Growth*

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Abstract

We quantify the role of capital-goods imports in U.S. growth. The premise is that capital-goods imports have been a driving force behind the decline in the price of investment in equipment and software. To quantify this gain, we build a neoclassical growth model with international trade in capital goods. In our model, agents face exogenous paths of total factor and investment-specific productivity. Investment-specific productivity is reflected by the price of capital-goods imports and the price of investment in domestically-produced equipment and software relative to the price of consumption. We use these prices to solve for optimal investment decisions and to understand the underlying sources of economic growth. The model suggests that capital-goods imports have contributed 15 percent to U.S. growth in output per hour since 1967. It also suggests that this contribution has increased significantly over the sample period, reaching 27 percent over the past ten years. In addition, we show that the U.S. could have lost up to 27 percent of growth in output per hour without trade in capital goods.

JEL classification codes: E2; F2; F4; O3; O4

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1 Introduction

In a seminal paper, Greenwood, Hercowitz and Krusell (1997)–(GHK) explore the role played by investment-specific technical change for generating postwar U.S. output growth. In their model, technical change is reflected by the decline in the price of investment in equipment and software (E&S) relative to the price of consumption. Using a standard neoclassical growth model, GHK estimated that technical change embodied in new capital goods accounted for nearly 60 percent of growth in U.S. output per hour during the postwar period. Their finding has precipitated a growing body of literature on investment-specific technical change as a major source of economic growth and fluctuations.\(^1\) In this context, it is natural to wonder what is behind the decline in the price of investment in E&S.

Over the last 40 years, the U.S has spent an increasing portion of its aggregate investment in E&S on capital-goods imports. The upper panel of Figure 1 displays the quantity ratios between capital-goods imports and GNP, and between aggregate investment in E&S and GNP.\(^2\) It shows that the ratio of capital-goods imports to GNP has increased since 1967. It also suggests that the share of capital-goods imports in aggregate investment in E&S has increased. During the same period, the price of capital-goods imports has declined relative to the price of investment in domestically-produced E&S. The lower panel of Figure 1 shows that the decline in the relative price of capital-goods imports has been substantially larger than the decline in the relative price of investment in domestically-produced E&S. Together, these observations suggest that capital-goods imports have been a driving force behind the decline in the price of aggregate investment in E&S relative to consumption.

This paper studies the quantitative role of capital-goods imports in U.S. output growth. We quantify this role in the context of a neoclassical growth model with international trade in capital goods. In our model, agents face exogenous paths of total factor productivity and investment-specific productivity. Investment-specific productivity is reflected by the price of capital-goods imports and the price of investment in domestically-produced E&S relative to the price of consumption. Given these prices, agents make investment decisions regarding imports of capital goods.


\(^2\)These quantities are quality-adjusted.
and expenditure on domestically-produced E&S. The general equilibrium approach allows us to understand the underlying sources of E&S growth and to quantify the role of capital-goods imports in U.S. output growth.

The model indicates that trade in capital goods has contributed 15 percent to U.S. growth in output per hour since 1967. It also suggests that this contribution has increased significantly over the sample period, rising from 8.8 percent between 1967 and 1987 to 26.8 between 1997 and 2007. At the same time, the contribution of investment in domestically-produced E&S to U.S. growth in output per hour has remained fairly constant. This phenomenon is both true in the data and in the simulated model.

We also use the model economy to perform a number of counterfactual experiments. First, we ask how much would U.S. output have grown without trade in capital goods. To answer this question, we assume that agents would only have faced the relative price of investment in domestically-produced E&S in making investment decisions. Under this scenario, the model predicts that the U.S. would have lost up to 27 percent of its growth rate in output per hour. We interpret this result as an upper bound since the U.S. would probably have produced a greater variety of E&S goods in the absence of trade in capital goods.

Why is the potential loss in U.S. growth in output per hour larger than the contribution of capital-goods imports? The reason is that U.S. aggregate investment in E&S would cost more if it was only produced domestically. With complementarities between E&S, structures, and labor implied by the production function, U.S. growth in output per hour would have been lower. Therefore, our findings are related to the large literature on investment prices and economic prosperity.3

The notion that trade in capital goods is an important source of economic fluctuations is not new. The international real business cycle literature, pioneered by the work of Backus, Kehoe, and Kydland (1992, 1994) and Baxter and Crucini (1993), focuses on the dynamics of investment to generate plausible business cycles. Later, Boileau (1999) and Raffo (2009) exploit movements in the prices of E&S to explain trade in capital goods and other aspects of international economic fluctuations. However, this literature does not address the contribution of trade in capital goods to economic growth.

Overall, our results suggest that capital-goods imports through their effect on the decline in the price of aggregate investment in E&S have had a significant impact on U.S. output growth since 1967. We do not interpret the decline in the relative price of capital-goods imports as fully reflecting investment-specific technical change originating from abroad. In part, the decline in the relative price of capital-goods imports may well reflect the creation, reallocation, and integration of global production facilities as in the vertical-specialization model of Yi (2003), as well as lower labor costs in emerging markets, and the reduction of tariffs and transportation costs. Nevertheless, from a U.S. point of view, the decline in the price of capital-goods imports is equivalent to technical change: It implies an increase in measured productivity gains.

The rest of the paper is organized as follows. Section 2 documents the dynamics of U.S. capital-goods since 1967. Section 3 presents our open-economy model. Section 4 describes the model’s solution, calibration, and estimation. Section 5 discusses the model’s performance and examines the quantitative role of capital-goods imports in U.S. output growth. Finally, Section 6 concludes.

2 Empirical Evidence

In this section, we measure the prices of investment in E&S and document the dynamics of capital-goods imports. The annual data are from National Income and Product Accounts (NIPA) and cover the period 1967 to 2007. Data are Fisher chain-weighted unless otherwise noted.

2.1 Measuring Prices of Investment in E&S

We measure investment-specific productivity from the ratios between the deflator in E&S and the consumption deflator. The consumption deflator is the implicit price deflator for the chain-weighted aggregate of private consumption on nondurables and services and government consumption. We do not include durables consumption in the consumption aggregate as to avoid the issue of accounting for quality improvement in consumer durables. The deflator for aggregate investment in E&S is the implicit price deflator for the chained-weighted sum of private and government non-residential fixed investment in E&S. The deflator for capital-goods imports is taken directly from the NIPA data. We compute the deflator for domestic E&S
investment as the implicit price deflator of the chain-weighted difference between aggregate investment in E&S and capital-goods imports. Real quantities of aggregate investment in E&S, investment in domestic E&S, and capital-goods imports are the counterparts of the implicit price deflators described above.

Related studies on the role of investment-specific technical changes have often used Gordon’s (1990) E&S prices. For example, Hulten (1992) and GHK measure the contribution of investment-specific technical changes to U.S. growth using a two-sector model based on Gordon’s E&S prices. Because this dataset only covers the postwar period until 1983, Hulten’s analysis is limited to that period. Instead, GHK extended Gordon’s E&S prices to 1992 by applying a constant adjustment factor to the NIPA series. Later, Cummins and Violante (2002) estimated quality bias in the NIPA series and updated Gordon’s E&S prices until 2000. They found that the quality bias in the NIPA series is largest for civilian aircrafts, engines, and parts, while the NIPA series for computers, peripherals, and parts is preferable. Importantly, civilian aircrafts, engines, and parts, and computers, peripherals, and parts are two of the three main components of the NIPA capital-goods imports series.

In contrast, Whelan (2002) uses the official NIPA series to measure the contribution of E&S to U.S. output growth. In addition, the Bureau of Economic Analysis (BEA) has implemented several revisions to its methodology in order to account for the rapid rate of innovation in E&S. In particular, hedonic regression techniques and the implementation of chained-weighting methodology by the BEA in the 1990’s were intended to allow aggregates to better track quality improvements over time. We acknowledge that accurate price measurements are central to our analysis. For our analysis, we choose to use the official NIPA data because of the recent updates to the BEA methodology and because computers, peripherals, and parts have become an important driver behind the growth of capital-goods imports and aggregate investment in E&S.\footnote{In addition, a simple extrapolation of Cummins and Violante’s method to capital-goods imports would be difficult. We would need Gordon’s data on quality adjusted series for capital-goods imports, a classification that is not available in Gordon’s study.}

### 2.2 Trends in Capital-Goods Imports

The upper panel of Figure 1 displays the ratios between capital-goods imports and GNP, and between aggregate investment in E&S and GNP. These ratios are based
on quality-adjusted quantities of capital-goods imports and aggregate investment in E&S. The panel suggests that the ratio of capital-goods imports to aggregate investment in E&S has increased significantly since 1967. While this ratio can be used to illustrate how capital-goods imports have grown relative to aggregate investment in E&S, it cannot be interpreted as a share. First, the sum of the ratios of chain-weighted aggregates does not equal one, except for the base year. Second, growth in the quantity of capital-goods imports has had a larger impact on growth of aggregate investment in E&S than it would have had using fixed-weight calculation. This is because the price of capital-goods imports has fallen faster than the price of investment in domestic E&S.

We look at two alternative indicators to understand the importance of capital-goods imports in the behavior of aggregate investment in E&S. The first indicator measures the amount of resources allocated to capital-goods imports. Figure 2 displays the expenditure shares of capital-goods imports in aggregate investment in E&S. It shows that capital-goods imports have accounted for an increasing fraction of aggregate expenditure in E&S over the last forty years: While accounting for a mere 3.5 percent in 1967, capital-goods imports have accounted for 37.4 percent of aggregate expenditure in E&S in 2007.

The second indicator captures the contribution of capital-goods imports to growth in aggregate investment in E&S. While we may not be able to add the components of aggregate investment in E&S to obtain its level, we can add the contribution to each of its components to obtain the change in the aggregate. Table 1 confirms that capital-goods imports have contributed importantly to aggregate investment in E&S. In fact, the average contribution of capital-goods imports to growth in aggregate investment in E&S has been 54 percent over the sample period. In addition, this contribution has increased over time. In particular, the contribution of capital-goods imports to growth in aggregate investment in E&S has increased from 11 percent between 1967 and 1987 to 70 percent between 1997 and 2007. The contribution in the latter period had increased for two reasons. First, the price of capital-goods has fallen more rapidly than the price of investment in domestic E&S. Second, the expenditure share of capital-goods imports in aggregate investment in E&S has risen in the second half of the sample.

The capital-goods imports series we use contains information on three cate-

\[5\] See Appendix A for calculation details.
categories\textsuperscript{6}: civilian aircrafts, engines, and parts; computers, peripherals, and parts; and other. In 2007, the category "other" contained two-thirds of the goods. This category includes electric generating machinery, electric apparatus and parts; oil drilling, mining, and construction machinery; scientific, hospital, and medical equipment and parts; telecommunication equipment; and semiconductors, among others. Nominal imports of computers, peripherals, and parts accounted for 25 percent of capital-goods imports.

Table 1 also shows each category’s contribution to the growth in capital-goods imports. From 1967 to 1987, most of growth in capital-goods imports was accounted for by civilian aircrafts, engines, and parts. However, from 1997 to 2007, most of growth in capital-goods imports was accounted for by computers, peripherals, and parts– while civilian aircrafts, engines, and parts ranked last. This surge in the contribution of computers, peripherals, and parts to capital-goods imports growth may be associated with the reduction in tariffs, and the creation and spread of global production in information technology industries as suggested by Feenstra, Reinsdorf, and Slaughter (2008).

3 The Model Economy

The model economy includes a representative household, a representative firm, and a government. The household makes consumption, labor supply, and investment decisions to maximize expected lifetime utility

$$E_t \left[ \sum_{i=0}^{\infty} \beta^i u(c_t, l_t) \right], \ 0 < \beta < 1,$$

given period $t$ utility function

$$u(c_t, l_t) = \theta \log c_t + (1 - \theta) \log (1 - l_t), \ 0 < \theta < 1.$$

In these equations, $c_t$ represents consumption of final output, $l_t$ represents labor hours, $\beta$ is the discount factor, and $\theta$ is the household’s share of utility received from consumption.

Each period, final output $y_t$ is produced using a constant-return-to-scale technology with inputs of labor hours $l_t$ and two types of capital, structures $k_{s,t}$ and E&S

\textsuperscript{6}Appendix A describes the category "other" in details.
The production technology for producing final output is of the Cobb-Douglas form

\[ y_t = a_t k_{s,t}^\alpha k_{e,t}^{1-\alpha}, \quad 0 < \alpha_s, \alpha_e < 1, \text{ and } \alpha_s + \alpha_e < 1, \]  

(3)

where \( a_t \) represents total-factor productivity, and \( \alpha_s \) and \( \alpha_e \) represents the income shares of structures and E&S. Final output is allocated to consumption, investment in structures \( i_{s,t} \), investment in domestic E&S \( i_{e,t} \), and capital-goods exports \( i_{x,t} \). Taking consumption as the numeraire, the resource constraint is given by

\[ y_t = c_t + i_{s,t} + p_{d,t} i_{d,t} + p_{x,t} i_{x,t}, \]  

(4)

where \( p_{d,t} \) represents the prices of investment in domestic E&S and \( p_{x,t} \) represents the price of capital-goods exports.\(^7\) We impose balanced trade to close the model. This implies that the value of capital-goods imports is equal to the value of capital-goods exports

\[ p_{m,t} i_{m,t} = p_{x,t} i_{x,t}, \]  

(5)

where \( i_{m,t} \) represents capital-goods imports and \( p_{m,t} \) represents its price in consumption units. This condition simplifies our model and is supported by the fact that the nominal trade balance in capital goods has been roughly balanced over the sample period as shown in Figure 3. After taking the balanced-trade condition (5) into account, the resource constraint becomes

\[ y_t = c_t + i_{s,t} + p_{d,t} i_{d,t} + p_{m,t} i_{m,t}. \]  

(6)

One new unit of structures costs one unit of final output. The law of motion for the stock of structures is

\[ k_{s,t+1} = i_{s,t} + (1 - \delta_s) k_{s,t}, \quad 0 < \delta_s < 1, \]  

(7)

where \( \delta_s \) represents the depreciation rate of structures. In contrast, one new unit of equipment costs \( p_{e,t} \) units of final output. Therefore, the law of motion for the stock of E&S is

\[ k_{e,t+1} = \frac{1}{p_{e,t}} i_{e,t} + (1 - \delta_e) k_{e,t}, \quad 0 < \delta_e < 1, \]  

(8)

where \( \delta_e \) represents the depreciation rate of E&S and \( 1/p_{e,t} \) represents investment-specific productivity. It determines the amount of new E&S that can be purchased

\(^7\)The price of investment in domestic E&S is not the same as the price of capital-goods exports.
for one unit of final output. Accordingly, fluctuations in $1/p_{e,t}$ reflects changes in the current state of technology for transforming investment in E&S into its stock.

We model aggregate investment in E&S as a CES composite:

$$i_{e,t} = \left( \phi^{1-p} i_{d,t}^p + (1-\phi)^{1-p} i_{m,t}^p \right)^{\frac{1}{p}}, \quad 0 < \phi < 1, \quad \rho < 1. \quad (9)$$

where $\phi$ represents the long-run share of investment in domestic E&S into aggregate investment in E&S, and $\rho$ determines the elasticity of substitution between investment in domestic E&S and capital-goods imports. The goal of the household is to minimize expenditure on E&S such that equation (9) holds. The solution to the minimization problem yields the following optimal investment quantities:

$$i_{d,t} = \phi \left( \frac{p_{d,t}}{p_{e,t}} \right)^{-\rho} i_{e}, \quad (10)$$

$$i_{m,t} = (1-\phi) \left( \frac{p_{m,t}}{p_{e,t}} \right)^{-\rho} i_{e}. \quad (11)$$

Given these optimal choices, the price of aggregate investment in E&S is

$$p_{e,t} = \left( \phi p_{d,t}^{-\frac{1}{p-1}} + (1-\phi) p_{m,t}^{-\frac{1}{p-1}} \right)^{\frac{1}{p-1}}. \quad (12)$$

This expression shows that the price of aggregate investment in E&S depends on the prices of investment in domestic E&S and of capital-goods imports. In the aggregate, the investment decisions depend on the domestic technology to produce E&S and on the measured productivity of capital-goods imports implied by their relative price.\(^8\)

Finally, the government raises taxes on labor at the rate $\tau_{l,t}$ and capital income at the rate $\tau_{k,t}$. It runs a balanced budget each period and tax revenues are rebated to households through a lump-sum transfer $g_t$. The budget constraint for the government is

$$g_t = \tau_{l,t} w_t l_t + \tau_{k,t} (r_{s,t} k_{s,t} + r_{e,t} k_{e,t}) \quad (13)$$

where $w_t$ represents the real wage, and $r_{s,t}$, and $r_{e,t}$ represents the real rates of return from structures and E&S.

\(^8\)Once the investment decisions are made, domestic E&S and capital-goods imports are added to the existing E&S stock. This assumption may seem ad-hoc, but it is consistent with the data on the stock of fixed assets from the BEA. The published data do not distinguish between the stock of E&S derived from domestically-produced E&S and the stock of E&S derived from capital-goods imports.
4 Matching the Model with the Data

This section presents the solution of the model’s competitive equilibrium. It also describes the data, and the calibration and estimation of some of the parameters.

4.1 Computation of a Dynamic Competitive Equilibrium

A competitive equilibrium is a sequence of prices \{p_{c,t}, w_t, r_{s,t}, r_{e,t}\}, and allocations \{c_t, l_t, i_{s,t}, i_{e,t}\} for the household, and \{l_t, k_{s,t}, k_{e,t}\} for the firm such that: (i) Given prices, the allocation \{c_t, l_t, i_{s,t}, i_{e,t}\} maximizes household’s utility, (ii) Given prices, the allocation \{l_t, k_{s,t}, k_{e,t}\} maximizes firm’s profit, and (iii) The resource constraint (6) is satisfied. Appendix B describes the equations of the resulting competitive equilibrium.

Together with the resource constraint, the household’s and the firm’s optimality conditions represent a system of equations that can be solved to find the equilibrium of the model economy. This equilibrium is characterized by one intratemporal equation which determines the amount of hours worked,

\[
\frac{(1 - \theta)}{\theta} c_t = (1 - l_t) \cdot (1 - \alpha_s - \alpha_e) \cdot \frac{y_t}{l_t}, \tag{14}
\]

and two intertemporal equations which determine the evolution in the stocks of structures and E&S,

\[
\frac{c_{t+1}}{c_t} = \beta \left( \alpha_s \cdot \frac{y_t}{k_{s,t}} + (1 - \delta_s) \right), \tag{15}
\]

\[
\frac{c_{t+1}}{c_t} = \beta \left( \alpha_e \cdot \frac{y_t}{p_{e,t}} \frac{1}{k_{e,t}} + (1 - \delta_e) \right). \tag{16}
\]

Solving for an equilibrium path involves choosing a sequence of consumption, hours worked, and investment in structures and E&S given the exogenous path of total factor productivity, the price of investment in domestic E&S, the price of capital-goods imports, the working age population, the initial stock of structures and E&S, and the transversality condition. To make the computation of an equilibrium tractable, we assume that the economy converges to its balanced-growth path. We solve the model starting in 1967 and let it run to 2050. From 2008 to 2050, we assume that total factor productivity, the price of investment in domestic E&S, the price of capital-goods imports, hours, and the working-age population grow at constant rates equal to their average growth rates between 1967 and 2007.
4.2 Data

Most of the data comes from NIPA as described in Section 2. Final output is defined as gross national product minus gross housing and business farm products. Because trade only occurs in capital goods, we add net exports (excluding capital goods) to final output.\(^9\) The employment series is Total Aggregate Hours: Non-Farm Payrolls (SAAR) from the Bureau of Labor Statistics. The population series is Resident Working Age Population: 15-64 years from the Census Bureau. Appendix A contains additional information on the data.

4.3 Calibration and Estimation

Table 2 presents the calibrated parameter values. We assume that the number of weekly hours available for market work is one hundred. This implies that the ratio of hours worked to non-sleeping hours is 0.217. It also implies that the growth rate of output per hours measured in consumption units is 0.77 percent.

Because of rapid quality improvements in E&S, we use physical depreciation rates in our capital accumulation equations as opposed to economic depreciation rates implied by BEA data. This is suggested by Cummins and Violante (2002) and follows the work of Oliner (1989), Gort and Wall (1998), and Whelan (2002). Economic depreciation measures the change in the value of an asset associated with the aging process and consists of an age and a time effect. Physical depreciation captures the age effect due to wear and tear. The time effect captures obsolescence due to the change in the relative price over time. Since there are no quality improvements in structures, and therefore no change in relative prices, physical depreciation in structures equals economic depreciation. In contrast, the physical depreciation rate in E&S evolves as

\[
\delta_{e,t} = 1 - (1 - d_{e,t}) \frac{p_{e,t-1}}{p_{e,t}},
\]

where \(\delta_{e,t}\) and \(d_{e,t}\) are physical and economic depreciation rates in E&S. We compute the economic depreciation rate in structures by dividing the depreciation rate of structures in year \(t\) by the stock of structures in year \(t - 1\). We compute the economic depreciation rate in E&S similarly. Economic depreciation rates are measured using current-dollar series. Figure 4 displays the physical and economic depreciation rates as well as the average physical depreciation rates of structures and E&S. The E&S

\(^9\)An alternative measure is to define final output as expenditure as in equation (6). This measure gives similar results.
economic depreciation rate trends upward from 13 percent in 1967 to 17 percent in 2008. In contrast, the physical depreciation rate in E&S is trendless at around 12 percent. The volatility in our measure of physical depreciation rate in E&S stems from the volatility in the relative prices of E&S. The average physical depreciation rates of structures and E&S are 2.5 and 12.4 percent. We use these averages to build our measures of capital stocks and to compute the dynamic implications of our model.\textsuperscript{10} We choose the averages rather than the series to isolate the role of relative price changes in investment decisions.

We follow Mendoza et al. (1994) and Gomme and Rupert (2007) and compute an average tax rate on labor income of 24.3 percent and an average tax rate on net capital income of 26.9 percent. We also follow Gomme and Rupert (2007) to obtain an average capital income share of 0.285. Also for these cases, we use the series averages to focus on investment decisions.

We assume that the ratio of capital-goods imports in aggregate investment in E&S has reached its steady-state level in the base year 2000. Therefore, we set $\phi$ to 0.664. This ratio is virtually equivalent to the average share of the last ten years of our data. Since the price of aggregate investment in E&S (12) in the model is not of the Fisher chain-weighted form, the elasticity of substitution between investment in domestic E&S and capital-goods imports comes from the solution to

$$P = \min \left( p_{e,t} - \overline{p}_{e,t} (\rho) \right)' W \left( p_{e,t} - \overline{p}_{e,t} (\rho) \right), \tag{18}$$

where $W$ is an identity matrix, $p_{e,t}$ is the Fisher chain-weighted price of aggregate investment in E&S from the data, and $\overline{p}_{e,t} (\rho)$ is the Fisher chain-weighted price of aggregate investment in E&S resulting from the optimal allocations of investment in domestic E&S (10) and capital-goods imports (11), with the corresponding prices taken from the data. Our estimate of the elasticity of substitution between investment in domestic E&S and capital-goods imports is 1.96. As shown in Figure 5, the CES quantities and the resulting Fisher chain-weighted price of aggregate investment in E&S match the data fairly well. This implies that if the model’s investment decisions in aggregate E&S were identical to those observed in the data, the optimal allocations resulting from the CES aggregate would be a good approximation to actual investment decisions.

\textsuperscript{10}We did not find any significant difference in capital stocks or in the behavior of the model using the series instead of their averages.
Finally, we use the method of moments to obtain the numerical values of the remaining four parameter. The estimated parameter values $\beta, \theta, \alpha_s, \alpha_e$ are the solution to

$$
M = \min (m_t - \hat{m}_t (\beta, \theta, \alpha_s, \alpha_e))^T W (m_t - \hat{m}_t (\beta, \theta, \alpha_s, \alpha_e)),
$$

where $m_t$ represents a vector of moments from the data, $\hat{m}_t (\beta, \theta, \alpha_s, \alpha_e)$ is the corresponding vector from the model, and $W$ is an identity matrix. The targets are the paths of output per hour, and the structures-per-hour and E&S-per-hour ratios over the period 1967 to 2007. We chose these targets because they are the variables we use to perform our growth accounting exercise.

Part of the estimation involves calculating total factor productivity given the income shares of structures and E&S. We compute total factor productivity using the production function (3). We construct the stocks of structures and E&S using the laws of motion (7) and (8). Starting with an initial value for $k_{s,1967}$ and $k_{e,1967}$, we compute the stock of structures and E&S by iterating on the laws of motion using observed investment values for $i_{s,t}$ and $i_{e,t}$ in consumption units. As starting values for the capital stocks, we use the stocks of structures and E&S observed in 1967 from the BEA Fixed Assets tables divided by the consumption deflator. In addition, the stock of E&S is quality-adjusted using the evolution in the price of aggregate investment in E&S.

The estimated parameter values are presented in Table 3. The discount factor implies an average after tax return on capital of 6 percent. The household’s share of utility received from consumption relative to the disutility from supplying labor is 0.275. Finally, the structures share of income is 0.162 while the E&S share of income is 0.123. These parameter values are standard in the literature.

Since the system is overidentified, we test the model using a Wald statistic under the hypothesis that the model represents the data generating process. The Wald test statistic is

$$
Q = T \cdot (m_t - \hat{m}_t (\beta, \theta, \alpha_s, \alpha_e))^T \hat{V} (m_t - \hat{m}_t (\beta, \theta, \alpha_s, \alpha_e)) \to \chi^2_{119},
$$

where $\hat{V}$ is the covariance matrix of the model’s paths and $T$ is the number of moments matched which is equal to 123. With 4 parameters to estimate, the

\[11\] The after tax return on capital is $g/\beta$ where $g$ is the economy average annual growth rate of output per hour.
system is overidentified and the test statistic follows a chi-square distribution with 119 degrees of freedom. \( Q \) is equal to 125.3 with an associated probability value of 0.33. Therefore, we cannot reject the model at conventional significance levels. Figure 6 displays the model’s paths of output per hour, and the structures- and E&S-per-hour ratios relative to the data. This figure confirms that the model fits the targets fairly well.

Figure 7 displays our measure of total factor productivity and compares the three measures of productivity: total factor productivity, the technology to produce domestically-purchased E&S, and the productivity implied by the relative price of capital-goods imports. The upper panel shows that total factor productivity displays steady growth throughout the sample periods with large drops during the recessions of 1970, 1975, 1980-1982, and 2001. Over the whole sample, the average annual growth rate of total factor productivity was 0.18 percent. The lower panel compares the three measures of productivity. It shows how rapid was the growth in investment-specific productivities compared to that of total factor productivity. Over the whole sample, the average annual rate of growth in the productivity of domestically-purchased E&S was 2.38, while the average annual rate of growth in the productivity implied by the price of capital-goods imports was 4.71. The average annual rate of growth in the productivity implied by the price of capital-goods imports was even faster after 1980, averaging 7.09 percent.

5 Quantitative Analysis

In this section, we assess the quantitative role of capital-goods imports in U.S. growth. First, we present the dynamic properties of our model. Second, we perform a growth accounting exercise to quantify the contribution of capital-goods imports to growth in U.S. output per hour. Finally, we perform a number of counterfactual experiments to illustrate the importance of trade in capital goods.

5.1 Dynamic Properties of the Model

Before performing our growth accounting exercise, we assess the ability of the model to replicate the main business cycle features and to match key aspects of our analysis. Table 4 presents the standard deviations and the correlations of consumption,
investment in structures and E&S, and hours worked relative to output. As shown in Table 4, the model does a good job at matching these moments.

The upper panel of Figure 8 presents the ratio of capital-goods imports to output and the ratio of aggregate investment in E&S to output for the data and the model economy. The model does a good job at capturing the upward trends in the ratios. The lower panel of Figure 8 displays the relative price of aggregate investment in E&S. The model captures the sustained decrease in the relative price of aggregate investment in E&S given the household’s optimal investment decisions over investment in domestic E&S and capital-goods imports.

Finally, Figure 9 displays the expenditure shares of investment in domestic E&S and capital-goods imports in aggregate investment in E&S. Importantly, the model captures the trends in the expenditure shares of investment in domestic E&S and capital-goods imports.

5.2 Growth Accounting

We now turn to our main question: what was the quantitative role of capital-goods imports in U.S. growth? To answer this question, we perform a growth accounting exercise and quantify the contribution of capital-goods imports to growth in U.S. output per hour. First, we rewrite the production function (3) as

\[
y_t = a_t \cdot \left( \frac{k_s t}{l_t} \right)^{\alpha_s} \cdot \left( \frac{k_e t}{l_t} \right)^{\alpha_e}. \tag{21}
\]

Then, by taking the natural logarithm of equation (21), we decompose output per hour into three additive factors:

\[
\log \frac{y_t}{l_t} = \log a_t + \alpha_s \log \left( \frac{k_s t}{l_t} \right) + \alpha_e \log \left( \frac{k_e t}{l_t} \right). \tag{22}
\]

This decomposition implies that U.S. growth in output per hour arises from growth in total factor productivity, and in the structure-per-hour and the E&S-per-hour ratios. To obtain the contribution of capital-goods imports, we use the CES composite (9) and compute the period \( t - 1 \) share of capital-goods imports in aggregate investment. We focus on the period \( t - 1 \) share because it takes one period for aggregate investment in E&S to materialize into stock. In other words, we are looking for the evolution in the accumulation of E&S attributable to capital-goods imports.
Table 5 presents the average annual growth rates in output per hour, total factor productivity, and structures, domestic E&S, and capital-goods imports predicted by the model. On average, the model predicts that growth in U.S. output per hour was 0.72 percent from 1967 to 2007. This number compares to 0.77 percent in the data. The model also predicts that growth in E&S was 0.43 which implies an average annual contribution of aggregate investment in E&S to U.S. growth in output per hour of 60.3 percent. This estimate is similar to Cummins and Violante (2002), GHK, Whelan (2003) and other studies who found that investment-specific technical change explained nearly 60 percent to U.S. growth in output per hour in the post-war period.

Table 6 presents the average annual contributions of growth in total factor productivity, structures, domestic E&S, and capital-goods imports to U.S. growth in output per hour. On average, the model predicts that capital-goods imports contributed 15 percent to U.S. output per hour over the period 1967 to 2007. This implies that capital-goods imports explained one quarter of the average annual contribution of aggregate investment in E&S to U.S. growth in output per hour.

The table also shows that this contribution has increased by three times over the sample period while the contribution of investment in domestic E&S has increased by a modest 24 percent. In fact, the contribution of capital-goods imports to U.S. growth in output per hour increased from 8.8 between 1967 and 1987 to 26.8 between 1997 and 2007, while the contribution of investment in domestic E&S to U.S. growth in output per hour increased from 42.3 percent between 1967 and 1987 period to 52.6 percent between 1997 and 2007.

Does growth in aggregate investment in E&S arise mostly from capital-goods imports as it is the case in the data? We provide an answer to this question in Table 7 which reports the model counterparts of Table 1’s average annual contributions of capital-goods imports to growth in aggregate investment in E&S. Table 7 shows that the model underpredicts the average annual contributions of capital-goods imports to aggregate investment in E&S between 1967 and 2007. However, a closer look at Table 7 reveals that while underpredicting the contribution between 1967 and 1997, the model overpredicts this contribution between 1997 and 2007. We conclude that the model’s simple investment decisions coming from changes in relative prices captures well the behavior of capital-goods imports in aggregate investment in E&S and its dynamics relative to output.
5.3 Counterfactuals

In this subsection, we perform two counterfactual experiments to illustrate the importance of trade in capital-goods. First, we ask how much would U.S. output have grown without access to trade in capital-goods. Second, we illustrate how trade policies could impact U.S. output growth.

5.3.1 U.S. Growth without Trade in Capital-Goods

How much would U.S. output have grown without access to trade in capital goods? To answer this question we assume that the U.S. would only have had access to the technology to produce domestically-purchased E&S. That is, we assume that the relative price of aggregate investment in E&S would have followed the relative price of investment in domestic E&S.

Under this scenario, the model predicts that average annual U.S. output per hour would have been 0.53 percent. This implies that the U.S. could have lost up to 27 percent of its growth rate without trade in capital goods. We interpret this finding has an upper bound because without trade, some capital goods could have well been produced in the U.S. and therefore would have contributed to U.S. output growth. At the same time, the model predicts that the contribution of investment in domestic E&S to U.S. growth in output per hour would have been 51.4 percent instead of the 60.3 percent suggested by the model with trade in capital-goods.

Why is the potential loss in U.S. growth in output per hour larger than the contribution of capital-goods imports? The reason is that U.S. aggregate investment in E&S would cost more if it was only produced domestically. With complementarities between E&S, structures, and labor implied by the production function, U.S. growth in output per hour would have been lower.

5.3.2 Trade Policies and U.S. Growth

[TO BE ADDED]
6 Conclusions

We showed that capital-goods imports had a significant impact on the price of E&S and on U.S. output growth. To quantify this gain, we build a neoclassical growth model with international trade in capital goods in which agents face exogenous paths of total factor and investment-specific productivity. Investment-specific productivity is reflected by the price of capital-goods imports and the price of investment in domestically-produced equipment and software relative to the price of consumption. We use observed prices to solve for optimal investment decision and understand the underlying sources of growth in the U.S. economy. The model indicates that capital-goods imports have contributed 15 percent to U.S. growth in output per hour between 1967 and 2007. This implies that capital-goods imports explained one quarter of the average annual contribution of aggregate investment in E&S to U.S. growth in output per hour.

The impact of capital-goods imports on the price of E&S may have been significant for short-run economic fluctuations. In closed-economy models, Greenwood, Hercowitz and Krusell (2000) and Fisher (2006) attribute a large fraction of business cycle volatility to fluctuations in the price of E&S. In addition, Justiniano and Primiceri (2008) show that most of the decline in business-cycle volatility observed since the mid-1980’s is driven by the decline in the volatility of innovations to the relative price of investment in E&S. The fact that capital-goods imports have contributed more than half to growth in aggregate investment in E&S since 1967 suggests that capital-goods imports might have played an important role in U.S. business cycle volatility.

Another topic of interest would be to understand the nature of the output gains stemming from capital-goods imports. For example, Feenstra (1994), Hummels and Klenow (2006), and Broda and Weinstein (2006) suggest that the increase in the variety of imports is an important phenomenon for which to account for. The model only considers the intensive margin of trade in capital goods: It has one type of capital-goods imports which are a perfect substitute for investment in domestic E&S. A natural extension of the model would consider the benefit from the extensive margin of capital-goods imports to U.S. growth.
A Data

A.1 Data

We obtained our data from the Bureau of Economic Analysis. Data on aggregate series are from NIPA Tables 1.1.3 to 1.1.5, 1.3.3. to 1.3.7, 1.5.3 to 1.5.7, and 1.7.3 to 1.7.7. Data on imports of capital goods are from NIPA Tables 4.2.4 to 4.2.7. Data on investment are from NIPA Tables 5.3.3 to 5.3.7. The capital stocks and the corresponding depreciations are from the Fixed Assets tables. The employment series is Total Aggregate Hours: Non-farm Payrolls (SAAR) from the Bureau of Labor Statistics. The population series is Resident Working Age Population: 15-64 years from the Census Bureau.

A.2 Computation of Contributions to Growth

Whelan (2002) shows that the growth rate of a chained aggregate can be expressed as the sum of the contribution of each of its components:

\[
\frac{\Delta q_t}{q_{t-1}} = \sum_{i=1}^{n} \frac{\left( p_{i,t-1} + p_{i,t}/\Pi_t \right) \cdot \Delta q_{i,t}}{\sum_{i=1}^{n} \left( p_{i,t-1} + p_{i,t}/\Pi_t \right) \cdot q_{i,t}} \tag{A1}
\]

\[
= \sum_{i=1}^{n} c_{i,t}.
\]

where \( q_t \) represents the quantity of the aggregate, \( q_{i,t} \) and \( p_{i,t} \) represents the quantity and price of its components, and \( \Pi \) is the growth rate of the aggregate deflator.

To calculate the contribution of a particular category to the change in the aggregate \( \Delta q_t \), we take the ratio of the component’s sum

\[
\sum_{t=T_0}^{T_1} c_{i,t}q_{t-1},
\]

relative to the aggregate sum

\[
\sum_{t=T_0}^{T_1} \sum_{i=1}^{n} c_{i,t}q_{t-1}
\]

over the period \( T_0 \) to \( T_1 \).
A.3 Capital-Goods Imports Categories

The table below documents the categories of capital-goods imports and their nominal values in 2007, seasonally-adjusted in million of dollars. The table comes from the NIPA-International Transaction Account Data, Table 2A. 1978 is the earliest year of available disaggregated data.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric generating machinery, electric apparatus and parts</td>
<td>9.4</td>
<td>11.4</td>
</tr>
<tr>
<td>Oil drilling, mining, and construction machinery</td>
<td>7.1</td>
<td>4.1</td>
</tr>
<tr>
<td>Industrial engines, pumps, and compressors</td>
<td>6.0</td>
<td>3.3</td>
</tr>
<tr>
<td>Machine tools and metalworking machinery</td>
<td>9.0</td>
<td>2.2</td>
</tr>
<tr>
<td>Measuring, testing, and control instruments</td>
<td>2.5</td>
<td>3.3</td>
</tr>
<tr>
<td>Other industrial, agricultural, and service industry machinery</td>
<td>27.2</td>
<td>18.5</td>
</tr>
<tr>
<td>Computers, peripherals, and parts</td>
<td>5.0</td>
<td>24.6</td>
</tr>
<tr>
<td>Semiconductors</td>
<td>9.3</td>
<td>6.8</td>
</tr>
<tr>
<td>Telecommunications equipment</td>
<td>8.7</td>
<td>9.7</td>
</tr>
<tr>
<td>Other office and business machines</td>
<td>6.2</td>
<td>2.3</td>
</tr>
<tr>
<td>Scientific, hospital, and medical equipment and parts</td>
<td>3.6</td>
<td>6.4</td>
</tr>
<tr>
<td>Civilian aircraft, engines, and parts</td>
<td>4.4</td>
<td>6.8</td>
</tr>
<tr>
<td>Others</td>
<td>1.7</td>
<td>0.6</td>
</tr>
</tbody>
</table>

B The Competitive Equilibrium

A competitive equilibrium is a sequence of prices \( \{p_{e,t}, w_t, r_{s,t}, r_{e,t}\} \), allocations \( \{c_t, l_t, i_{s,t}, i_{e,t}\} \) for the household and allocations \( \{l_t, k_{s,t}, k_{e,t}\} \) for the firm such that:

(i) Given prices, the allocation \( \{c_t, l_t, i_{s,t}, i_{e,t}\} \) maximizes household’s utility, (ii) Given prices, the allocation \( \{l_t, k_{s,t}, k_{e,t}\} \) maximizes firm’s profit, and (iii) the resource constraint (6) is satisfied.
(i) The household chooses consumption, leisure, and investment in structures and E&S to maximizes utility

\[ \theta \log c_t + (1 - \theta) \log (1 - l_t), \quad (B1) \]

given the budget constraint, law of motions for the stocks of structures and E&S, initial capital stocks, non-negativity constraints

\[ c_t + i_{s,t} + i_{e,t} \leq (1 - \tau_l) w_t l_t + (1 - \tau_k) (r_{s,t} k_{s,t} + r_{e,t} k_{e,t}) + g_t, \quad (B2) \]

\[ k_{s,t+1} = i_{s,t} + (1 - \delta_s) k_{s,t}, \quad (B3) \]

\[ k_{e,t+1} = q_{e,t} i_{e,t} + (1 - \delta_e) k_{e,t}, \quad (B4) \]

\[ c_t, l_t, k_{s,t}, k_{e,t} \geq 0, \; l_t \leq 1, \]

\[ k_{s,T_0}, k_{e,T_0} \geq 0, \quad (B5) \]

where \( q_{e,t} = 1/p_{e,t} \). Substituting (B3) into (B2), the maximization problem can be represented by the following Lagrangian:

\[ L = \max_{c_{t}, l_t, k_{s,t+1}, k_{e,t+1}} \sum_{t=0}^{\infty} \beta^t \left[ \theta \log c_t + (1 - \theta) \log (1 - l_t) \right] + \]

\[ \beta^t \lambda_{t+1} \left[ (1 - \tau_l) w_t l_t + (1 - \tau_k) (r_{s,t} k_{s,t} + r_{e,t} k_{e,t}) + \right. \]

\[ \left. (1 - \delta_s) k_{s,t} + (1 - \delta_e) (r_{s,t} k_{s,t} + r_{e,t} k_{e,t}) + g_t - c_t - k_{s,t+1} - \frac{k_{e,t+1}}{q_{e,t}} \right] \quad (B6) \]

The first order conditions are:

\[ c_t : \quad \frac{\theta}{c_t} - \lambda_t = 0 \]

\[ : \quad c_t = \frac{\theta}{\lambda_t} \quad (B7) \]

\[ l_t : \quad -\frac{(1 - \theta)}{(1 - l_t)} + \lambda_t (1 - \tau_l) w_t = 0 \]

\[ : \quad \frac{(1 - \theta)}{\theta} c_t = w_t (1 - \tau_l) (1 - l_t) \quad (B8) \]

\[ k_{s,t+1} : \quad -\lambda_t + \beta \lambda_{t+1} (r_{s,t} + (1 - \delta_s)) = 0 \]

\[ : \quad \frac{\lambda_t}{\beta \lambda_{t+1}} = (1 - \tau_k) r_{s,t} + (1 - \delta_s) \]

\[ \Rightarrow : \quad \frac{c_{t+1}}{\beta c_t} = (1 - \tau_k) r_{s,t} + (1 - \delta_s) \]

20
The system of equation as:

determines the amount of hours worked,

Combining the household’s and the firm’s optimality conditions, and the resource constraint, we specify a system of equations that can be solved to find the equilibrium of the model. The economy is described by one intratemporal equations which determines the amount of hours worked,

and two intertemporal equations which determine the evolution of the capital stocks of structures and E&S,

These correspond to the paper’s equations (14) to (16). Using the resource constraint (6) we solve for \( c_t \)

Define \( \Phi_t \equiv (k_{s,t+1} - (1 - \delta_s) k_{s,t}) - (k_{e,t+1} - (1 - \delta_e) k_{e,t}) / q_{e,t} \), and rewrite the system of equation as:

\[
\frac{(1 - \theta)}{\theta} y_t - \Phi_t = (1 - \tau_r) (1 - l_t) \cdot (1 - \alpha_s - \alpha_e) \cdot \frac{y_t}{l_t},
\]
\[
\frac{y_{t+1} - \Phi_{t+1}}{y_t - \Phi_t} = \beta \left( (1 - \tau_k) \cdot \alpha_s \cdot \frac{y_t}{k_{s,t}} + (1 - \delta_s) \right), \quad (B20)
\]

\[
\frac{y_{t+1} - \Phi_{t+1}}{y_t - \Phi_t} = \beta \left( q_{e,t} (1 - \tau_k) \left( \alpha_e \cdot \frac{y_t}{k_{e,t}} \right) + (1 - \delta_e) \right). \quad (B21)
\]

These are the equations we use to solve the model.
References


### Table 1: Contributions from Capital-Goods Imports to Growth in E&S

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Capital-goods Imports</td>
<td>0.54</td>
<td>0.11</td>
<td>0.64</td>
<td>0.70</td>
</tr>
<tr>
<td>Capital-Goods Imports from...</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Civilian aircraft, engines, and parts</td>
<td>0.27</td>
<td>0.66</td>
<td>0.24</td>
<td>0.19</td>
</tr>
<tr>
<td>Computer, peripherals, and parts</td>
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<td>0.03</td>
<td>0.37</td>
<td>0.53</td>
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<tr>
<td>Other</td>
<td>0.31</td>
<td>0.31</td>
<td>0.39</td>
<td>0.27</td>
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Table 2: Baseline Calibration

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<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>$l$</td>
<td>Ratio of hour worked to non-sleeping hours</td>
<td>0.217</td>
</tr>
<tr>
<td>$\alpha_s + \alpha_c$</td>
<td>Capital share of income</td>
<td>0.285</td>
</tr>
<tr>
<td>$\delta_s$</td>
<td>Structures annual depreciation rate</td>
<td>0.025</td>
</tr>
<tr>
<td>$\delta_e$</td>
<td>E&amp;S annual depreciation rate</td>
<td>0.124</td>
</tr>
<tr>
<td>$\tau_l$</td>
<td>Tax rate on labor income</td>
<td>0.243</td>
</tr>
<tr>
<td>$\tau_k$</td>
<td>Tax rate on capital income</td>
<td>0.269</td>
</tr>
<tr>
<td>$\phi$</td>
<td>Long-run domestic-to-total investment in E&amp;S ratio</td>
<td>0.664</td>
</tr>
<tr>
<td>$\frac{1}{1-\rho}$</td>
<td>Elasticity of subst. between domestic and imported investment in E&amp;S</td>
<td>1.964</td>
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Table 3: Estimated Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
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<th>Value</th>
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<tbody>
<tr>
<td>$\theta$</td>
<td>Household’s share of utility received from consumption</td>
<td>0.275</td>
</tr>
<tr>
<td>$\beta$</td>
<td>Discount factor</td>
<td>0.951</td>
</tr>
<tr>
<td>$\alpha_s$</td>
<td>Structures share of income</td>
<td>0.162</td>
</tr>
<tr>
<td>$\alpha_e$</td>
<td>E&amp;S share of income</td>
<td>0.123</td>
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</table>
### Table 4: Moments

<table>
<thead>
<tr>
<th>Standard deviation relative to output</th>
<th>Data</th>
<th>Model</th>
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<tbody>
<tr>
<td>Consumption</td>
<td>0.93</td>
<td>0.83</td>
</tr>
<tr>
<td>Investment in structures</td>
<td>0.04</td>
<td>0.08</td>
</tr>
<tr>
<td>Aggregate investment in E&amp;S</td>
<td>0.19</td>
<td>0.12</td>
</tr>
<tr>
<td>Investment in domestic E&amp;S</td>
<td>0.10</td>
<td>0.06</td>
</tr>
<tr>
<td>Capital-goods imports</td>
<td>0.08</td>
<td>0.07</td>
</tr>
<tr>
<td>Hours worked</td>
<td>0.02</td>
<td>0.02</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Correlation relative to output</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption</td>
<td>0.99</td>
<td>0.99</td>
</tr>
<tr>
<td>Investment in structures</td>
<td>0.86</td>
<td>0.72</td>
</tr>
<tr>
<td>Aggregate investment in E&amp;S</td>
<td>0.97</td>
<td>0.97</td>
</tr>
<tr>
<td>Investment in domestic E&amp;S</td>
<td>0.99</td>
<td>0.64</td>
</tr>
<tr>
<td>Capital-goods imports</td>
<td>0.92</td>
<td>0.95</td>
</tr>
<tr>
<td>Hours worked</td>
<td>0.99</td>
<td>0.99</td>
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</tbody>
</table>
Table 5: Average Annual Growth in U.S. Output per Hour-Worked

<table>
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<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Output per hour</td>
<td>0.72</td>
<td>0.57</td>
<td>0.88</td>
<td>0.81</td>
</tr>
<tr>
<td>Total factor productivity</td>
<td>0.18</td>
<td>0.17</td>
<td>0.35</td>
<td>0.01</td>
</tr>
<tr>
<td>Structures</td>
<td>0.11</td>
<td>0.11</td>
<td>0.05</td>
<td>0.16</td>
</tr>
<tr>
<td>Domestic E&amp;S</td>
<td>0.32</td>
<td>0.24</td>
<td>0.37</td>
<td>0.42</td>
</tr>
<tr>
<td>Capital-goods imports</td>
<td>0.11</td>
<td>0.05</td>
<td>0.11</td>
<td>0.22</td>
</tr>
</tbody>
</table>
Table 6: Average Annual Contribution to Growth in U.S. Output per Hour-Worked (%)

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Total factor productivity</td>
<td>24.7</td>
<td>30.2</td>
<td>39.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Growth in structures</td>
<td>15.0</td>
<td>18.7</td>
<td>5.4</td>
<td>20.1</td>
</tr>
<tr>
<td>Growth in domestic E&amp;S</td>
<td>45.3</td>
<td>42.3</td>
<td>42.7</td>
<td>52.6</td>
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<tr>
<td>Growth in capital-goods imports</td>
<td>15.0</td>
<td>8.8</td>
<td>12.6</td>
<td>26.8</td>
</tr>
</tbody>
</table>
Table 7: Average Annual Contributions from Capital-Goods Imports to Growth in Aggregate Investment in E&S

<table>
<thead>
<tr>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Data*</td>
<td>0.54</td>
<td>0.11</td>
<td>0.64</td>
<td>0.70</td>
</tr>
<tr>
<td>Model</td>
<td>0.45</td>
<td>0.03</td>
<td>0.54</td>
<td>0.79</td>
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* from Table 1
Figure 1: Relative quantities and relative prices of non-residential fixed investment in E&S.
Figure 2: Expenditure shares of investment in domestic E&S and capital-goods imports in aggregate investment in E&S.
Figure 3: Terms of trades and nominal trade balances
Figure 4: Economic and physical depreciation rates in structures and E&S
Figure 5: Data vs CES: Quantities of investment in domestic E&S and capital-goods imports, and the price of aggregate investment in E&S.
Figure 6: Data vs Model–Estimation targets
Figure 7: Productivity measures
Figure 8: Data vs Model: Relative quantities and relative prices of investments in E&S
Figure 9: Expenditure shares of investment in domestic E&S and capital-goods imports in aggregate investment in E&S