Investment Demand and Structural Change*

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Abstract

The sectoral composition of GDP is largely affected by the investment rate of the economy. Using Input-Output data for a panel of countries we present two novel facts consistent with this idea: (a) investment goods contain more domestic value added from manufacturing and less from services than consumption goods do, (b) the evolution of the sectoral composition of investment and consumption goods differs from the one of GDP. A multi-sector growth model estimated with a panel of countries shows that changes in investment demand are quantitatively important to understand the industrialization of several countries since 1950, the deindustrialization of many Western economies since 1970, and the hump-shaped relationship between manufacturing and development, which has been a challenge for theories of structural change under balanced growth. The different composition of investment and consumption goods can also explain up to 1/2 of the decline in its relative price since 1980.

JEL classification: E23; E21; O41

Keywords: Structural Change; Investment; Growth; Transitional Dynamics

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1 Introduction

The economic development of nations begins with a rise in industrial production and a relative decline of agriculture, followed by a decrease of the industrial sector and a sustained increase of services.\footnote{The description of this process traces back to contributions by Kuznets (1966) and Maddison (1991). See Herrendorf, Rogerson, and Valentinyi (2014) and references therein for a detailed description of the facts.} Because this structural transformation is relatively slow and associated with long time periods, the recent growth literature has studied changes in the sectoral composition of growing economies along the balanced growth path, that is to say, in economies with constant investment rates.\footnote{Kongsamut, Rebelo, and Xie (2001) study the conditions for structural change due to demand non-homotheticities to happen under balanced growth, while Ngai and Pissarides (2007) model the role of asymmetric productivity growth. Boppart (2014) combines both mechanisms with different types of preferences to characterize the balanced growth path equilibrium. In contrast, a third mechanism of structural change emphasized in the recent literature—the heterogeneity of production functions across sectors—is incompatible with balanced growth paths. However, Acemoglu and Guerrieri (2008) and Alvarez-Cuadrado, VanLong, and Poschke (2018) show that the aggregate dynamics are quantitatively close to it.}

However, within the last 60 years a significant number of countries have experienced long periods of growth that may be well characterized by transitional dynamics. For instance, Song, Storesletten, and Zilibotti (2011) and Buera and Shin (2013) document large changes in the investment rate of China and the so-called Asian Tigers over several decades after their development process started. Interestingly, these same countries experienced a sharp pattern of sectoral reallocation during the period, which suggests that deviating from the balanced growth path hypothesis might be relevant when thinking about the causes and consequences of structural transformation.

In this paper we provide a first step in understanding the relationship between changes in the investment rate and changes in the sectorial composition of developing economies. To do so we start by documenting two novel facts by use of Input-Output (IO) tables from the World Input-Output Database (WIOD) for 40 countries between 1995 and 2011. First, we show that the set of goods used for final investment is different from the set of goods used for final consumption. Specifically, taking the average over all countries and years, 55% of the domestic value added used for final investment comes from the industrial sector, while 42% comes from services. In contrast, only 15% of domestic value added used for final consumption comes from industry, while 80% come from services. Therefore, investment goods are 40 percentage points more intensive in value added from the industrial sector than consumption goods. Second, we document that there is structural change within both consumption and investment goods, but that the process is more
intense within consumption goods. Furthermore, the standard hump-shaped profile of manufacturing with development is absent when looking at investment and consumption goods separately.

Given these facts, we propose a new mechanism to account for the evolution of sectoral shares with development: because investment goods are different from consumption goods, changes in the investment rate change the relative demand of value added from different sectors. This is an extensive margin of structural change, as opposed to the intensive margin given by the change of the sectoral composition of consumption and investment goods. We show that the extensive margin of structural change is quantitatively important, even in the limited time span of mostly developed countries for which data is available in the WIOD. The mechanism is likely to be even more relevant for countries behind the technology frontier, countries whose investment rate changes substantially. Indeed, García-Santana, Pijoan-Mas, and Villacorta (2018) show that the investment rate follows a long-lasting hump-shaped profile with development, and we show that the peak of the hump of investment happens at a similar level of development as the peak in the hump of manufacturing.

To quantify the importance of this mechanism for a wider set of countries and years without access to IO data, we use a standard three-sector neo-classical growth model that allows for structural change within investment and consumption goods due to changes in sectoral prices and due to non-homothetic demands. In addition, given the potentially different sectoral composition of investment and consumption goods, the change in the investment rate outside the balanced growth path is a third reason for sectoral reallocation. We use the demand system of the model to estimate the parameters characterizing the sectoral composition of investment and consumption goods. The theory leads naturally to our identification assumption: conditional on sectoral prices and the level of development, the sectoral composition of the economy does not affect the investment rate, hence the conditional correlation between the investment rate and the sectoral composition of GDP identifies the difference in sectoral composition between consumption and investment goods. We perform the estimation with an unbalanced panel of 48 countries between 1950 and 2011 constructed with data from the World Development Indicators (WDI) and the Groningen 10 Sector Database (G10S). We find that this simple model fits well the time series data for most countries and therefore is able to reproduce the observed hump of manufacturing with development. Furthermore, the estimated sectoral composition of investment and consumption goods resembles the one measured directly in the WIOD for the periods and countries available in the two data sets. This gives credence to the results for countries and years for which IO data are not available. Once we have measured
the unobserved sectoral composition of consumption and investment goods for all countries and years, we decompose each country’s observed changes in sectoral composition into their intensive margin, i.e., changes within consumption and investment, and their extensive margin components, i.e., changes in the investment rates.

Our results imply that the changes in investment demand are quantitatively important for structural change, especially for economies in transition. First, increases in the investment rate account for a large part of the increase in the size of the industrial sector for some selected development episodes. Among them, South Korea, Malaysia, and Thailand until the early 90’s, China and India since the early 50’s, Japan and Taiwan until the early 70’s, and Indonesia (1965-2011), Paraguay (1962-1980) and Vietnam (1987-2007). For this group of countries and years, the share of the manufacturing sector increased on average by 18.6 percentage points, of which 1/2 is accounted for by the increase in the investment rate, 1/5 by the increase in manufacturing within investment and consumption, and the rest by the increase in exports and the change of export composition. Second, the investment decline since the 70’s in some rich countries also helps explain the contraction of their manufacturing sectors. In particular, this was the case in Japan, Finland, Germany, Sweden, Denmark, and Austria since the early 70’s or Singapore, Philippines and Argentina since the late 70’s or early 80’s. On average, these countries saw a decline in manufactures of 9.5 percentage points, of which 2/3 came from the decline of the investment rate.

Third, when looking at the data for all countries together, we show that the evolution of the investment rate accounts for a substantial part of the hump in manufactures. In the data, the share of industrial value added increases by 25 percentage points when countries move from a GDP per capita of around $700 to an income level of $8,800, and declines by 20 percentage points as GDP per capita increases up to $67,000 (international dollars base 2005). The estimated model reproduces well this hump. We find that the change of the investment rate accounts for 1/3 of the increase and 1/5 of the decline, while structural change within consumption and investment accounts for 1/5 of the increase and 1/2 of the decline. Changes in the level and composition of exports account for the rest. There is a number of papers describing economic mechanisms that could potentially generate a hump in manufacturing for closed economies under balanced growth path, which in our framework would map into structural change within consumption goods. The Ngai and Pissarides (2007) model with different constant rates of growth in sectoral productivities may lead to humps in value added shares of those sectors with intermediate rates of productivity growth. Within the demand-side explanations for structural change, the well-known model with Stone-Geary preferences of Kongsamut, Rebelo, and Xie (2001)
cannot generate a hump in manufacturing. However, there are ways of modelling non-homotheticities that can generate the hump, as for instance the hierarchic preferences in Foellmi and Zweimuller (2008), the scale technologies in Buera and Kaboski (2012b), or the non-homothetic CES preferences in Comin, Lashkari, and Mestieri (2015). All these mechanisms require the hump of manufacturing value added to be present within consumption goods. Our story instead allows for the share of manufacturing value added within final consumption goods to be monotonic, with the hump in the economy-wide share of manufacturing coming from the hump in the investment rate. Our empirical evidence finds only weak hump-shaped profiles of the share of manufacturing value added within consumption. In terms of consumption expenditure, Herrendorf, Rogerson, and Valentinyi (2014) only find a mild hump for the very long time series of UK and US, but there is no clear hump for other countries. We take this as evidence in favor of the extensive margin channel. Our results suggest that open economy models may also contribute to produce a hump of manufacturing in GDP that is absent in consumption through an extensive margin of structural change based on exports instead of investment.3

Our final result is that the different composition of investment and consumption goods is also consequential for the evolution of their relative price. Karabarbounis and Neiman (2014) show that the relative price of investment goods declined substantially over the 1980-2010 period. One way to incorporate this pattern in macro models is by thinking of an acceleration in exogenous investment-specific technical progress.4 However, technical progress is not a characteristic of the final use given to a good but of the type of good produced. We show that between 1/4 and 1/2 of the decline of the relative price of investment goods since the 80’s can be accounted for by the relative decline in the price of manufactures and the fact that investment goods are more intensive in manufactures than consumption goods. In other words, the relative increase in productivity of manufacturing sector broadly defined accounts for between 1/4 and 1/2 of what has been labelled as investment-specific technical change. The rest should come from the different composition of the manufactures used for final investment and for final consumption.

Finally, a recent paper by Herrendorf, Rogerson, and Valentinyi (2018) measures the evolution of the sectoral shares within consumption and investment by use of the long time

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3For instance, Uy, Yi, and Zhang (2014) argue that sectoral specialization due to productivity growth and international trade can generate a hump of manufacturing in GDP, although their quantitative exercise with Korean data cannot reproduce the falling part of the hump. Matsuyama (2017) model of trade and non-homothetic demands may also generate a hump of manufacturing in developing economies through sectoral specialization and international trade if the price-elasticity of manufactured goods is in between the ones of agriculture and services, although no measurement is provided.

series of IO data for the US. Their results resemble our findings both in WIOD and WDI-G10S data. Our paper differs from theirs in two fundamental aspects. First, we focus on understanding structural change in countries where the extensive margin matters, while they concentrate on the US, whose dynamics are reasonably close to a Balanced Growth Path (BGP). In that sense, they provide theoretical results showing that a BGP with structural change within investment requires non-constant sectoral productivity growth, and they characterize the properties of such a BGP. And second, we develop an empirical strategy to estimate the sectoral composition of different goods without access to IO data, while they rely on the measurement of these sectoral compositions in the IO data. To our knowledge, they are also the first ones to use the terms intensive and extensive margins of structural change, which we have borrowed for this version of our paper.

The remaining of the paper is organized as follows. In Section 2 we show the key empirical facts from the WIOD that motivate the paper. In Section 3 we outline the model and in Section 4 we discuss its estimation. Then, in Section 5 we present our results. Finally, Section 6 concludes.

2 Some Facts

In this section we present empirical evidence of the three key facts that motivate the paper. As it is standard in this literature, we divide the economy in three sectors: agriculture, industry, and services, and use the term manufacturing and industry interchangeably to denote the second of them, which includes: mining; manufacturing; electricity, gas, and water supply; and construction.\(^5\)

2.1 Sectoral composition of investment and consumption goods

The first piece of evidence that we put together is the different sectoral composition of the goods used for final investment and final consumption. To do so, we use the World Input Output Database (WIOD), which provides IO tables for 35 sectors, 40 countries (mostly developed), and 17 years (between 1995 and 2011).\(^6\) To give an example of what we do, let’s think of how final investment goods may end up containing value added from the agriculture sector. Agriculture goods are sold as final consumption to households and as exports, but not used directly for gross capital formation. However, most of the output from the agriculture sector is sold as intermediate goods to several industries, the main

\(^5\)See Appendices A and B for details.

\(^6\)A detailed explanation of the WIOD can be found in Timmer, Dietzenbacher, Los, Stehrer, and de Vries (2015).
### Table 1: Sectoral composition of investment and consumption goods.

<table>
<thead>
<tr>
<th></th>
<th>investment ((x))</th>
<th>consumption ((c))</th>
<th>difference ((x - c))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Agr</td>
<td>Ind</td>
<td>Ser</td>
</tr>
<tr>
<td>mean</td>
<td>2.8</td>
<td>54.8</td>
<td>42.4</td>
</tr>
<tr>
<td>(p_{10}) (NLD)</td>
<td>0.6</td>
<td>40.0</td>
<td>59.4</td>
</tr>
<tr>
<td>(p_{50}) (IND)</td>
<td>9.4</td>
<td>53.9</td>
<td>36.6</td>
</tr>
<tr>
<td>(p_{90}) (MEX)</td>
<td>3.9</td>
<td>66.5</td>
<td>29.6</td>
</tr>
</tbody>
</table>

Notes: The first row reports the average over all countries and years of the value added shares of investment and consumption goods. The next rows report the average over time of three particular countries (Netherlands, India, and Mexico). These countries are chosen as the 10th, 50th, and 90th percentiles of the distribution of the differential intensity of industrial sector between investment and consumption goods.

five being—according to the IO Table for the US in the year 2000, and excluding agriculture itself—“Food, Beverage, and Tobacco”, “Wood and Products of Wood”, “Pulp, Paper, Printing and Publishing”, “Hotels and Restaurants”, and “Textile” industries. In turn, a fraction of the output from the “Wood and Products of Wood”, “Pulp, Paper, Printing and Publishing”, and “Textile” industries is sold to the “Electrical and Optical Equipment” and “Transport Equipment” industries. Finally, around 20% of the output of the “Electrical and Optical Equipment” and “Transport Equipment” industries goes to final investment. In Appendix B we explain how to obtain the sectoral composition of each final good following a standard procedure explained for instance by Herrendorf, Rogerson, and Valentinyi (2013).

We find that investment goods are more intensive in industrial value added than consumption goods are. In particular, taking the average over all countries and years, the value added share of industrial sectors is 55% for investment goods and 15% for consumption goods, a difference of almost 40 percentage points. The flip side of this difference is apparent in services, which represent 42% of investment goods and 80% of consumption goods, see Table 1. There is some cross-country heterogeneity, but the different sectoral composition between investment and consumption goods is large everywhere. For instance, investment has 31% more of value added from manufacturing than consumption in Netherlands (the 10% lowest in the sample) and almost 49% in Mexico (the 10% highest).
Figure 1: Sectoral shares for different goods, within-country evidence

Notes. Sectoral shares from WIOD (dots) and projections on a quadratic polynomial of log GDP per capita in constant international dollars (lines). Data have been filtered out from country fixed effects.

2.2 Evolution of the sectoral composition of consumption and investment

The second piece of evidence we want to emphasize is the evolution of the sectoral composition of investment and consumption goods with the level of development. In particular, we show that (a) there is structural change within both investment and consumption goods, but it is stronger within consumption goods, (b) the different composition of investment and consumption goods in terms of manufacturing and services widens with development, and (c) the standard hump-shaped profile of manufacturing with development is more apparent for the whole economy than for the investment and consumption goods separately.

To document these facts we pool the WIOD data for all countries and years and exploit its longitudinal dimension by regressing sectoral shares against a polynomial of log GDP per capita (in 2005 international dollars) and country fixed effects. In Figure 1 we plot the
resulting sectoral composition for investment (red), consumption (blue), and total output (black) against log GDP per capita, after filtering out the cross-country differences in levels. We first observe that the WIOD is consistent with the standard stylized facts of structural change: for the whole GDP there is a secular decline of agriculture, a secular increase in services, and a (mild) hump of manufacturing. When looking at the pattern of sectoral reallocation within each good, we observe that the share of agriculture declines faster in consumption than in investment, that the share of services increases faster in consumption than in investment, and that the share of manufacturing declines somewhat faster in consumption than in investment. These patterns imply that structural change is sharper within consumption than within investment and that the asymmetry between consumption and investment goods in terms of their content of manufacturing and services widens with development. Finally, it is important to note that the hump of manufacturing within GDP is happening neither within investment (the quadratic term is non-significant) nor within consumption (the increasing part is missing). The comparison of the share of manufacturing within investment and consumption with the share of manufacturing for the whole GDP is more clear in Panel (a) of Figure 2, which puts together the pics in Panel (e) and (f) of Figure 1.

2.3 The investment rate and the sectoral composition of the economy

Lastly, we want to characterize the relationship between the investment rate and the sectoral composition of the economy. We start by using the same WIOD data as in the last 2 sub-sections. In Panel (b) of Figure 2 we plot the investment rate (blue line) against
the level of development after filtering out country fixed effects. We observe a hump of investment with the level of development. For comparison, Panel (a) shows the share of manufacturing in GDP (black line) and the share of manufacturing within consumption (blue) and investment (red). The correlation between the share of manufacturing and the investment rate is large: 0.50 for the pooled raw data and 0.36 when controlling for country fixed effects.

A more clear pattern of the relationship between investment and sectoral composition of the economy emerges by using a wider set of countries and years. To do so, we use investment data from the Penn World Tables (PWT) and sectoral data from the World Development Indicators (WDI) and the Groningen 10-Sector Database (G10S) for a large panel of countries.\footnote{See Section 4.3 for details on the data series and the sample construction. Feenstra, Inklaar, and Timmer (2015) and Timmer, de Vries, and de Vries (2014) provide a full description of the PWT and G10S respectively.} We pool together the data of all countries and years and filter out

\textit{Notes.} Sectoral shares from G10S and WDI and investment rate from PWT—all at current prices—(dots) and projections on a quadratic polynomial of log GDP per capita in constant international dollars (lines). Data have been filtered out from country fixed effects. Each color and shape represents data from a different country.
cross-country differences in levels by regressing the investment rate against log GDP per capita and country fixed effects. In Figure 3 we plot the resulting sectoral composition against the level of development. In Panels (a) and (b) we observe the clear declining and rising monotonic patterns of agriculture and services, while in Panel (c) we observe the clear hump-shaped profile of the value added share of industry.

Next, in Panel (d) of Figure 3 we plot the investment rate in each country-year against the level of development, also after filtering out cross-country differences in levels. We observe a clear hump-shaped profile of investment with the level of development: poor countries invest a small fraction of their output, but as they develop the investment rate increases up to a peak and then it starts declining. Note that the hump is long-lived (it happens while GDP multiplies by a factor of 90), it is large (the investment rate increases by 15 percentage points), and it is present for a wide sample of countries (48 countries at very different stages of development). The large hump of investment with the level of development has already been documented by García-Santana, Pijoan-Mas, and Villacorta (2018). What is interesting here is that the hump in industrial production in Panel (c) is very similar in size to the hump in investment in Panel (d), with the peak happening at a similar level of development. Indeed, the correlation between the value added share of industry and the investment rate is 0.44 in the raw data pooling all countries and years, and 0.55 when controlling for country fixed effects.

2.4 A novel mechanism for structural change

The facts described above highlight the potential importance of an extensive margin of structural change and suggest a possible explanation for the hump in manufacturing. Standard forces of structural change like non-homotheticities and asymmetric productivity growth may explain sectoral reallocation within investment and within consumption goods. But because investment goods are more intensive in value added from manufacturing than consumption goods, the hump-shaped profile of the investment rate generates a further force of structural change. Consistent with this mechanism, the hump of manufacturing is more apparent for the whole economy than for the consumption and investment goods separately.

While the WIOD data may not be ideal to study structural change because of the short time dimensions and the small number of developing countries, we can still use it to have a first assessment of this mechanism. To do so we start by using National Accounts
identities to note that the value added share of sector $i$ within GDP can be written as,

$$\frac{VA_i}{GDP} = \left( \frac{VA^x}{GDP} \right) \left( \frac{VA^x_i}{VA^x} \right) + \left( \frac{VA^c}{GDP} \right) \left( \frac{VA^c_i}{VA^c} \right) + \left( \frac{VA^e}{GDP} \right) \left( \frac{VA^e_i}{VA^e} \right)$$

(1)

which is a weighted sum of the sectoral share within investment $\frac{VA^x_i}{VA^x}$, within consumption $\frac{VA^c_i}{VA^c}$, and within exports $\frac{VA^e_i}{VA^e}$. The first two are the objects that we have documented in Table 1 and in Panel (a), (c), and (e) of Figure 1. The weights are the domestic investment rate $\frac{VA^x}{GDP}$, domestic consumption rate $\frac{VA^c}{GDP}$, and domestic exports rate $\frac{VA^e}{GDP}$. The domestic investment rate (and analogously the domestic consumption and export rates) is the ratio of the domestic valued added that is used for final investment. This is different from the investment spending over GDP of National Accounts, $\frac{X}{GDP}$, because part of the investment spending buys imported valued added (either directly by importing final investment goods, or indirectly by importing intermediate goods that will end up in investment through the IO structure of the economy). Indeed, one can write:

$$\frac{VA^x}{GDP} = \frac{VA^x}{X} \frac{X}{GDP}; \text{ and } \frac{VA^c}{GDP} = \frac{VA^c}{C} \frac{C}{GDP}; \text{ and } \frac{VA^e}{GDP} = \frac{VA^e}{E} \frac{E}{GDP};$$

where $X$, $C$, and $E$ are the expenditure in investment, consumption, and exports. While by construction the domestic investment rate will be weakly smaller than the actual investment rate, in Panel (b) of Figure 2 we show that the evolution of both magnitudes presents a similar hump with the level of development. Hence, structural change can happen because there is a change in the sectoral composition of investment, consumption or export goods (the intensive margin) or because there is a change in the investment, consumption or export demand of the economy (the extensive margin).

To decompose the evolution of sectoral shares into the intensive and extensive margins, we do two complementary exercises. In both exercises we build two counterfactual series for each sectoral share of the economy, in which only the intensive or extensive margin are active. In the first exercise, which we call “open economy”, the intensive margin counterfactual holds the 1st, 3rd and 5th terms of the right hand side of equation (1) equal to their country averages, while the extensive margin counterfactual holds constant the 2nd, 4th, and 6th terms. In the second exercise, which we call “closed economy”, we first build counterfactual sectoral shares omitting exports and imports as follows,

$$\tilde{VA}_i \frac{VA_i}{GDP} = \frac{X}{X + C} \left( \frac{VA^x_i}{VA^x} \right) + \frac{C}{X + C} \left( \frac{VA^c_i}{VA^c} \right)$$

(2)

Then, we build the intensive margin counterfactual by holding the 1st and 3rd terms in
Table 2: Decomposition of structural change.

<table>
<thead>
<tr>
<th>Sector</th>
<th>Data</th>
<th>Open economy</th>
<th>Closed economy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
<td>Int</td>
<td>Ext</td>
</tr>
<tr>
<td>Agriculture</td>
<td>-26.2</td>
<td>-26.2</td>
<td>-24.4</td>
</tr>
<tr>
<td>Industry</td>
<td>-6.1</td>
<td>-6.1</td>
<td>-16.0</td>
</tr>
<tr>
<td>Services</td>
<td>32.3</td>
<td>32.3</td>
<td>40.4</td>
</tr>
</tbody>
</table>

Notes: rows show the change in percentage points of the corresponding sectoral share as economies develop. The Data column reports the change implied by the polynomial of log GDP in Panel (b), (d), (f) of Figure 3. The other columns report the same statistic for several counterfactual series, see text and footnote 8.

equation (2) equal to their average and the extensive margin counterfactual by holding constant the 2nd and 4th terms.

We report in Table 2 the average importance of the intensive and extensive margin of structural change across the 40 countries and 17 years. In the first column we report the average change in the share of Agriculture (decline of 26 percentage points), Industry (decline of 6.1 percentage points), and Services (increase of 32.3 percentage points) across all countries and years as described in Figure 1. In the third and fourth columns we report the change accounted for by the intensive and extensive margins in the “open economy” exercise. We find that the extensive margin is important for the evolution of the industrial and service sectors. For instance, sectoral reallocation within each consumption, investment, and exports would have implied a decline of industry value added of 16 percentage points, a fall almost 10 percentage points larger than what we observe. Instead, the variation in investment, consumption, and export rates pulled the demand for industrial value added upwards for those 10 percentage points. In the fifth column we report the changes in sectoral shares implied by the closed economy through equation (2). We see that the sectoral shares of the closed economy pose a good approximation to the actual ones, with the implied changes in the relative size of sectors differing from the actual ones in less than two percentage points for services and less than one percentage point for agriculture and industry. Finally, in the sixth and seventh columns we report the decomposition in the “open economy” exercise, which abstracts from movements of imports, exports, and their composition. The results still show the importance of the

8These changes comes from treating the counterfactual series as the actual data: we pool all years and countries together and keep the relationship between sectoral share and log GDP after filtering out country fixed effects.
extensive margin in the evolution of the services and manufacturing shares.

Not all countries have experienced large changes in the investment rate over the short period covered by the WIOD. To highlight the importance of the extensive margin of structural change for some countries and years, in Figure 4 we report the evolution of the share of the industrial sector in India and China (black line) alongside with the counterfactual evolution of the intensive (blue) and extensive (green) margins. In panels (a) and (c) we report the counterfactual exercises for the “open economy” exercise and in panels (b) and (d) for the “closed economy” exercise. We can see that in both countries and for both exercises the intensive margin predicts a steady decline of manufacturing of around 4 percentage points in the space of 17 years. However, the actual sectoral evolution in these countries has no trend as they both experienced a sharp increase between 2002 and 2006, which is completely explained by the extensive margin.
3 The Model

We want to assess the relative importance of the intensive and extensive margin of structural change for a wider sample of countries and years than the WIOD sample. The problem we face is that without IO data we cannot directly observe the different sectoral composition of consumption and investment goods. In this Section we present an extended version of the canonical multi-sector neo-classical model of growth, whose structure will allow us to estimate the unobservable sectoral compositions of consumption and investment goods. The model features a static part that determines the sectoral composition of investment and consumption given the path of investment, and a dynamic part that determines the investment path. As we argue in Section 3.5 only the former needs to be fully specified.

The economy consists of three different sectors: agriculture, manufacturing, and services, indexed by $i = \{a, m, s\}$. Output $y_{it}$ of each sector can be used both for final consumption $c_{it}$ and for final investment $x_{it}$. An infinitely-lived representative households rents capital $k_t$ and labor (normalized to one) to firms and chooses how much of each good to buy for consumption and investment satisfying the standard budget constraint:

\begin{equation}
    w_t + r_t k_t = \sum_{i=\{a,m,s\}} p_{it} (c_{it} + x_{it})
\end{equation}

where $p_{it}$ is the price of output of sector $i$ at time $t$, $w_t$ is the wage rate, and $r_t$ is the rental rate of capital. Capital accumulates with the standard law of motion

\begin{equation}
    k_{t+1} = (1 - \delta) k_t + x_t
\end{equation}

where $0 < \delta < 1$ is a constant depreciation rate, and $x_t \equiv X_t(x_{at}, x_{mt}, x_{st})$ is the amount of efficiency units of capital produced with a bundle of goods from each sector. The period utility function $u(c_t)$ is defined over a consumption basket $c_t \equiv C(c_{at}, c_{mt}, c_{st})$ that aggregates goods from the three sectors. We will use a standard CRRA utility function,

\begin{equation}
    u(c_t) = \frac{c_t^{1 - \sigma} - 1}{1 - \sigma}
\end{equation}

and specify standard (potentially) non-homothetic CES aggregators for investment and
consumption:

\[ X_t(x_a, x_m, x_s) = \chi_t \left[ \sum_{i \in \{a,m,s\}} (\theta_i^x)^{1-\rho} x_i^\rho \right]^{\frac{1}{\rho}} \]  

(6)

\[ C(c_a, c_m, c_s) = \left[ \sum_{i \in \{a,m,s\}} (\theta_i^c)^{1-\rho} (c_i + \bar{c}_i)^\rho \right]^{\frac{1}{\rho}} \]  

(7)

with \( 0 < \theta_i^j < 1 \) and \( \sum_{i \in \{a,m,s\}} \theta_i^j = 1 \) for \( j = c, x, i = a, m, s \). For simplicity we restrict the elasticity parameter \( \rho < 1 \) to be equal in the aggregation of consumption and investment, but we allow the sectoral share parameters in consumption \( \theta_i^x \) to differ from the sectoral share parameters in investment \( \theta_i^x \). We also introduce the terms \( \bar{c}_i \) in order to allow for non-homothetic demands for consumption. Much of the literature has argued that these non-homotheticities are important to fit the evolution of the agriculture and service shares of the economy.\(^9\) Finally, \( \chi_t \) captures exogenous investment-specific technical change, a feature that is shown to be quantitatively important in the literature, see Greenwood, Hercowitz, and Krusell (1997) or Karabarbounis and Neiman (2014). The literature in structural change has typically assumed that either the aggregators for consumption and investment are the same, that the investment goods are only produced with manufacturing value added, or that the investment good is a fourth type of good produced in a fourth different sector.\(^10\)

3.1 Objective and FOC

With all these elements in place the optimal household plan is the sequence of consumption and investment choices that maximizes the discounted infinite sum of utilities. We can

\(^9\)Agricultural goods are typically modelled as a necessity (\( \bar{c}_a < 0 \)) because of the strong decline in the share of agriculture with development. Emphasizing this non-homotheticity within consumption goods is also consistent with the micro data evidence showing that the budget share for food decreases as household income increases. See for instance Deaton and Muellbauer (1980), Banks, Blundell, and Lewbel (1997), or Almás (2012). Services instead are typically modelled as luxury goods (\( \bar{c}_s > 0 \)) because their share increases with development. A typical interpretation is that services have easy home substitutes and households only buy them in the market after some level of income. See for instance Rogerson (2008) and Buera and Kaboski (2012a).

write the Lagrangian as,

$$
\sum_{t=0}^{\infty} \beta^t \left\{ u(c_t) + \lambda_t \left[ w_t + r_t k_t - \sum_{i=a,m,s} p_{it} (c_{it} + x_{it}) \right] + \eta_t \left[ (1 - \delta) k_t + x_t - k_{t+1} \right] \right\}
$$

where $\lambda_t$ and $\eta_t$ are the shadow values at time $t$ of the budget constraint and the law of motion of capital respectively. Taking prices as given, the standard first order conditions with respect to goods $c_{it}$ and $x_{it}$ are:

$$
u' (c_t) \frac{\partial c_t}{\partial c_{it}} = \lambda_t p_{it} \quad i \in \{a, m\} \quad (8)
$$

$$
\eta_t \frac{\partial x_t}{\partial x_{it}} = \lambda_t p_{it} \quad i \in \{a, m\} \quad (9)
$$

while the FOC for capital $k_{t+1}$ is given by,

$$
\eta_t = \beta \lambda_{t+1} r_{t+1} + \beta \eta_{t+1} (1 - \delta) \quad (10)
$$

### 3.2 Consumption choices

Using the utility function in equation (5) and the consumption aggregator in equation (7), the FOC of each good $i$ described by equation (8) can be rewritten as:

$$
\frac{c_t - \sigma}{c_t} \left( \theta_i^c \frac{c_t}{c_{it} + \bar{c}_i} \right)^{1-\rho} = \lambda_t p_{it}
$$

We can aggregate them (raising to the power $\frac{\rho}{\rho-1}$ and summing them up) to obtain the FOC for the consumption basket,

$$
\frac{c_t - \sigma}{c_t} = \lambda_t p_{ct} \quad (11)
$$

where $p_{ct}$ is the implicit price of the consumption basket defined as:

$$
p_{ct} \equiv \left[ \sum_{i=a,m,s} \theta_i^c p_{it}^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}} \quad (12)
$$

Adding up the FOC for each good $i$ we obtain,

$$
\sum_{i=a,m,s} p_{it} c_{it} = p_{ct} c_t - \sum_{i=a,m,s} p_{it} \bar{c}_i
$$
which states that total expenditure in consumption goods is equal to the value of the consumption basket minus the value of the non-homotheticities. Finally, using the ratio of the FOC’s given by equation (8) we obtain the expenditures shares relative to the consumption basket

\[
p_{it}c_{it} = \frac{c_{it}}{c_{it} + \bar{c}_i} \left( \frac{p_{it}}{p_{it}} \right)^{\frac{\rho}{1-\rho}}
\]

and relative to total consumption expenditure

\[
\frac{p_{it}c_{it}}{\sum_{j=a,m,s} p_{jt}c_{jt}} = \theta_i^{c} \left( \frac{p_{it}}{p_{it}} \right)^{\frac{\rho}{1-\rho}} \left[ 1 + \frac{\sum_{j=a,m,s} p_{jt}\bar{c}_j}{\sum_{j=a,m,s} p_{jt}c_{jt}} \right] - \frac{p_{it}\bar{c}_i}{\sum_{j=a,m,s} p_{jt}c_{jt}}
\]

### 3.3 Investment choices

Using the aggregator in equation (6), the FOC of each good \(i\) described by equation (9) can be rewritten as:

\[
\eta_t^{\rho} \left( \frac{\theta_i^{x} x_{it}}{x_{it}} \right)^{1-\rho} = \lambda_t p_{it}
\]

Following similar steps as for consumption we get the FOC for total investment,

\[
\eta_t = \lambda_t p_{xt}
\]

where

\[
p_{xt} \equiv \frac{1}{\chi_t} \left[ \sum_{i=a,m,s} \theta_i^{x} p_{it}^{\rho-1} \right]^{\frac{\rho}{\rho-1}}
\]

and the total expenditure equation,

\[
p_{xt}x_t = \sum_{i=a,m,s} p_{it}x_{it}
\]

Finally, the actual composition of investment expenditure is obtained from the ratio of the FOC of each good \(i\) described by equation (9),

\[
\frac{p_{it}x_{it}}{p_{xt}x_t} = \theta_i^{x} \left( \frac{\chi_t p_{xt}}{p_{it}} \right)^{\frac{\rho}{1-\rho}}
\]

### 3.4 Sectoral shares

In a closed economy output is used for consumption and investment only: \(y_{it} = c_{it} + x_{it}\). Hence, the sectoral shares of the economy at current prices are given by the following
identities:

\[
\frac{p_{it}y_{it}}{p_t y_t} = \frac{p_{it}x_{it}}{p_{xt} x_t} \frac{p_{xt} x_t}{y_t} + \frac{p_{it}c_{it}}{\sum_{j=a,m,s} p_{jt} c_{jt}} \left( 1 - \frac{p_{xt} x_t}{y_t} \right) \quad i \in \{a, m, s\}
\]  

(17)

where \( y_t \equiv \sum_{i=a,m,s} p_{it} y_{it} \) is GDP. This states that the value added share of sector \( i \) in GDP is given by the share of sector \( i \) within investment times the investment rate plus the share of sector \( i \) within consumption times the consumption rate. The sectoral shares within consumption and investment are obtained from the demand system of the static problem, see equations (13) and (16). Using the expressions for \( p_{ct} \) and \( p_{xt} \) in equations (12) and (15) we can obtain,

\[
\frac{p_{it}c_{it}}{\sum_{j=a,m,s} p_{jt} c_{jt}} = \left[ \sum_{j=a,m,s} \theta^c_j \left( \frac{p_{it}}{p_{jt}} \right)^{r^c_p} \right]^{-1} \left[ 1 + \sum_{j=a,m,s} p_{jt} c_{jt} \right] - \frac{p_{it}c_{it}}{\sum_{j=a,m,s} p_{jt} c_{jt}}
\]  

(18)

\[
\frac{p_{it}x_{it}}{p_{xt} x_t} = \left[ \sum_{j=a,m,s} \theta^x_j \left( \frac{p_{it}}{p_{jt}} \right)^{r^x_p} \right]^{-1}
\]  

(19)

Therefore, structural change will happen because of sectoral reallocation within consumption goods, because of sectoral reallocation within investment goods, and because of changes in the investment rate in transitional dynamics. The larger the difference in sectoral composition between investment and consumption goods, the stronger this latter effect.

3.5 Aggregate dynamics

Plugging equations (11) and (14) into (10) we get the Euler equation,

\[
c_t^{-\sigma} = \beta c_{t+1}^{-\sigma} \frac{p_{xt+1}}{p_{ct+1}} \frac{p_{ct}}{p_{xt}} \left[ \frac{r_{t+1}}{p_{xt+1}} + (1 - \delta) \right]
\]  

(20)

which states that the value of one unit of consumption today must equal the value of transforming that unit into capital, renting the capital to firms, and consuming the proceeds next period. The term in square brackets in the right-hand-side is the investment return in units of the investment good. When divided by the increase in the relative price of consumption it becomes the investment returns in units of the consumption good, which is the relevant one for the Euler equation.

The dynamic behavior of the aggregate variables is described by the Euler equation
of consumption (20) and the law of motion for capital (4), which we can rewrite as

\[ k_{t+1} = (1 - \delta) k_t + \frac{y_t}{p_{xt}} - \frac{p_{ct}}{p_{xt}} c_t + \sum_{i=a,m,s} \frac{p_{it}}{p_{xt}} \bar{c}_i \]  

where we are using the equilibrium condition that investment equals output minus consumption expenditure, \( p_{xt} x_t = y_t - \sum_{j=a,m,s} p_{jt} c_{jt} \). The aggregate dynamics described by these two difference equations in consumption and capital depend on aggregate output \( y_t \) and on all the prices of the economy: the interest rate \( r_t \), the sectoral prices \( p_{it} \), and the prices for consumption \( p_{ct} \) and investment \( p_{xt} \). Equations (12) and (15) show that these last two prices in turn are function of the sectoral prices \( p_{it} \) and the exogenous investment-specific technical change \( \chi_t \). To determine the evolution of aggregate output \( y_t \), the interest rate \( r_t \) and the sectoral prices \( p_{it} \) one needs to close the economy with a production side.

Herrendorf, Herrington, and Valentinyi (2015) show that the growth process of the US since 1950 can be well approximated by Cobb-Douglas sectoral production functions with equal capital shares, which is the canonical case considered for instance by Kongsamut, Rebelo, and Xie (2001) or Ngai and Pissarides (2007). In Appendix D we show that in this case the relative prices of sectors would be given by the inverse of exogenous relative productivities, and the aggregate output and the interest rate would be fully determined by aggregate capital and exogenous productivities. This means that, given sectoral productivities, the sectoral composition of the economy would have no effect on the dynamics of the aggregate variables and in particular on the evolution of the investment rate. Instead, the evolution of the investment rate would be solely determined by the particular dynamics of sectoral productivities and of investment-specific technical change. In turn, the hump in manufacturing would appear because of the hump in the investment rate itself (the extensive margin of structural change) or because of humps within consumption and/or investment goods through changes in sectoral productivities (the intensive margin of structural change).

The situation would be different if production functions differed across sectors in their capital share as in Acemoglu and Guerrieri (2008) or in their elasticity of substitution between capital and labor as in Alvarez-Cuadrado, VanLong, and Poschke (2017). Then, relative sectoral prices would depend on the capital intensity of the economy as well as on exogenous relative productivities, while aggregate output and the interest rate would depend on the size of different sectors of the economy. In this case, there would be scope for the sectoral shares to affect the aggregate dynamics of the economy and
in particular the dynamics of the investment rate. Hence, the correlation between the share of manufacturing and the investment rate presented in Figure 3 may partly reflect causality from manufacturing to investment. That being said, Acemoglu and Guerrieri (2008) and Alvarez-Cuadrado, VanLong, and Poschke (2018) show that their models with unequal sectoral production functions display structural change with close to balanced growth path dynamics; that is to say, they find that, quantitatively, changes in the sectoral composition of the economy have little effect on the investment rate.

As a final comment, the hump-shaped profile of the investment rate documented in Figure 3 is at odds with the monotonic decline predicted by the standard one-sector neoclassical growth model, see Antràs (2001). The literature trying to explain the evolution of the investment rate in economies in transition is long and diverse.\footnote{Christiano (1989), King and Rebelo (1993), and Carroll, Overland, and Weil (2000) argue that the hump can be produced by tweaking household preferences (Stone-Geary utility function or habit formation); Chen, Imrohoroglu, and Imrohoroglu (2006) show that the hump in Japan can be explained by the actual path of total factor productivity; Chang and Hornstein (2015) show that the increase of investment in South Korea can largely be explained by the trajectory of investment-specific technical change; Buera and Shin (2013) explain the investment hump in several Asian countries by financial frictions together with a product market liberalization.} Because neither our empirical strategy nor the measurement of the importance of the extensive margin needs to model the actual fluctuations of the investment rate outside the balanced growth path, we choose not to take a stand on the production side of the economy.

4 Estimation

We use the demand system of the model to estimate the parameters in the aggregators of consumption and investment for each country so that the identification of the model parameters comes from the longitudinal variation in each country’s aggregate variables.

With IO data one could build separate time series for the sectoral composition of investment and consumption and estimate the parameters of each aggregator separately by use of equations (18) and (19). This empirical strategy is analogous to Herrendorf, Rogerson, and Valentinyi (2013), who apply it to consumption for US postwar data, and to the more recent Herrendorf, Rogerson, and Valentinyi (2018), who also apply it to investment. Because we do not have IO tables for the wide range of countries and years that we use for our estimation, our alternative approach is to use time series for the sectoral composition of the whole GDP and estimate the model parameters by use of equation (17), which relates the sectoral shares for aggregate output with the investment rate and the unobserved sectoral shares within goods. In particular, combining equation...
with equations (18) and (19) we get one estimation equation for each sector \( i = m, s \):

\[
\frac{p_{it}y_{it}}{y_t} = g^x_i (\Theta^x; P_t) \frac{p_{xt}x_t}{y_t} + g^c_i (\Theta^c; P_t, p_{ct}^\hat{c}_t) \left( 1 - \frac{p_{xt}x_t}{y_t} \right) + \varepsilon_{it} \tag{22}
\]

where the \( g^c_i \) and \( g^x_i \) functions represent the sectoral shares within consumption and within investment given by equations (18) and (19), \( \Theta^c \) and \( \Theta^x \) are the vectors of parameters relevant for the consumption and investment aggregators, \( P_t \) is the vector of sectoral prices, \( p_{ct}^\hat{c}_t \equiv \sum_{i=\{a,m,s\}} p_{it}c_{it} \) is the consumption expenditure driving the non-homotheticity, and \( \varepsilon_{it} \) may be interpreted as measurement error in the aggregate sectoral shares.

The covariance between investment rate and sectoral composition is critical for identification. As an example, consider the simplest case where \( \rho = 0 \) and \( \bar{c}_i = 0 \). In this situation, the shares of sector \( i \) into consumption goods and into investment goods are just given by \( \theta^x_i \) and \( \theta^c_i \). Consequently, the value added share of sector \( i \) is given by,

\[
\frac{p_{it}y_{it}}{y_t} = \theta^x_i \frac{p_{xt}x_t}{y_t} + \theta^c_i \left( 1 - \frac{p_{xt}x_t}{y_t} \right) + \varepsilon_{it} = \theta^x_i + (\theta^x_i - \theta^c_i) \frac{p_{xt}x_t}{y_t} + \varepsilon_{it}
\]

This expression shows that with homothetic demands and unit elasticity of substitution between goods, the standard model delivers no structural change under balanced growth path—that is to say, whenever the investment rate is constant. However, the model allows for sectoral reallocation whenever the investment rate changes over time and \( \theta^x_i \neq \theta^c_i \). A simple OLS regression of the value added share of sector \( i \) against the investment rate of the economy identifies the two parameters, with the covariance between investment rate and the share of sector \( i \) identifying the differential sectoral intensity \( (\theta^x_i - \theta^c_i) \) between investment and consumption.

In the general setting described by equations (22), a non-linear estimator that exploits moment conditions like

\[
E[\varepsilon_{it}|P_t, p_{ct}^\hat{c}_t, p_{xt}x_t/y_t] = 0 \tag{23}
\]

will deliver consistent estimates of the parameters. This means that conditional on \( P_t \) and \( p_{ct}^\hat{c}_t \)—which fix the sectoral composition of consumption and investment goods—the covariance between the investment rate and the sectoral composition of GDP allows to estimate our model without IO data. Note that with \( P_t \) and \( p_{ct}^\hat{c}_t \) fixed, the model still allows for movements in the investment rate because of movements on the investment-specific technical change \( \chi_t \), movements in the interest rate \( r_t \), and movements in total output \( y_t \). The only concern for our empirical strategy would be if there be strong model mis-specification errors in equations (18) and (19) and at the same time the investment
rate depended on the sectoral composition of the economy, as in a model without identical Cobb-Douglas production functions. In that situation estimates may be biased. Hence, our identification assumption is that either there is no mis-specification in the demand side of the model or that sectoral production functions are Cobb-Douglas with equal capital shares.

4.1 Open economy extension

Our estimation approach comes from an accounting identity of a closed economy. If the export and import rates of the economy were correlated with the investment rate, then the identification condition (23) would be violated creating an omitted variable bias in the estimation. To take this into account, we write an open economy extension of our estimation equation (22), which comes from an approximation to equation (1).\(^{12}\) In particular,

\[
\frac{p_{it}y_{it}}{y_t} = g_i^x (\Theta^x; P_t) \frac{p_{xt}x_t}{y_t + p_{dt}d_t} + g_i^c (\Theta^c; P_t, p_{ct}c_t) \frac{p_{ct}c_t}{y_t + p_{dt}d_t} + \frac{p_{it}e_{it}}{p_{et}e_t} \frac{p_{et}e_t}{y_t + p_{dt}d_t} + \varepsilon_{it}
\]

where \(e\) and \(d\) refer to exports and imports respectively. In this equation everything can be measured in the data except for the value added share of exports, \(\frac{p_{it}e_{it}}{p_{et}e_t}\). Therefore, in our estimation approach we model the sectoral value added shares of exports in each country as a logistic function that depends on a low order polynomial on calendar time.\(^{13}\) For sector \(i = m, s\),

\[
\frac{p_{it}e_{it}}{p_{et}e_t} = g^e (\Theta^e, t) + \varepsilon_{it}
\]

\[
g^e (\Theta^e, t) \equiv \frac{\exp (\beta_0^e + \beta_1^e t)}{1 + \exp (\beta_0^e + \beta_1^e t)}
\]

while for sector \(i = a\) we can just write \(\frac{p_{at}e_{at}}{p_{et}e_t} = 1 - \frac{p_{at}e_{at}}{p_{et}e_t} - \frac{p_{at}e_{at}}{p_{et}e_t}\).

Then, the full model that we bring to the data is a system of aggregate sectoral share equations that consist of the industry share equation and the services share equation. For \(i = m, s\):

\[
\frac{p_{it}y_{it}}{y_t} = g_i^x (\Theta^x; P_t) \frac{p_{xt}x_t}{y_t + p_{dt}d_t} + g_i^c (\Theta^c; P_t, p_{ct}c_t) \frac{p_{ct}c_t}{y_t + p_{dt}d_t} + g^e (\Theta^e, t) \frac{p_{et}e_t}{y_t + p_{dt}d_t} + \nu_{it} \tag{24}
\]

\(^{12}\) See details of this approximation in Section B.2 and B.3 of Appendix B.

\(^{13}\) We model these sectoral shares as logistic functions to ensure that the shares lie between 0 and 1. A more parsimonious approach would have been to model the sectoral composition of exports as constant; however, the composition of exports typically changes with development, so to better fit the data we allow these sectoral compositions to vary over time.
where \( \nu_{it} \equiv \frac{p_{e,t} e_{t}}{y_{t} + p_{d,t} d_{t}} e^{v_{t}} + \varepsilon_{it} \).

4.2 Estimation procedure

The econometric framework that we consider is very non-linear with parameter constraints, which makes a Generalized Method of Moments (GMM) estimation problematic. For this reason we estimate the model in a Bayesian fashion and use Markov Chain Monte Carlo methods (MCMC) for computation. We use flat priors (non-informative priors) in order to obtain results which, absent numerical problems, would be as in the GMM framework.\(^{14}\) We simulate the MCMC using random walk Metropolis-Hasting because the non-linearity of the model prevents us from deriving closed form solutions for the posterior distributions. We follow an iterative procedure to set the initial values and the proposal distributions of the random-walk Metropolis-Hasting, and run our chains for 150,000 draws for each country.\(^{15}\)

4.3 Data and sample selection

Regarding the data definitions, we take the investment rate \( \frac{p_{x,t} x_{t}}{y_{t}} \), consumption rate \( \frac{p_{c,t} c_{t}}{y_{t}} \), export rate \( \frac{p_{e,t} e_{t}}{y_{t}} \), and import rate \( \frac{p_{d,t} d_{t}}{y_{t}} \) in local currency units (LCU) at current prices from the Penn World Tables (PWT). For the value added sectoral shares \( \frac{p_{v,t} v_{t}}{y_{t}} \) we use the series in LCU at current prices from two different data sets: the World Development Indicators (WDI) and the Groningen 10 Sector Database (G10S). We obtain the sectoral prices \( p_{it} \) as the implicit price deflators from the series of sectoral shares at current and at constant prices, and divide them by the GDP implicit price deflator in LCU. The choice of WDI or G10S is country-specific and based on the length of the time series available (if at all) in each data set. Finally, we use the GDP per capita in constant LCU as our measure of output \( y_{t} \) in the estimation, and the per capita GDP in constant international dollars as our measure of development in all figures, with both measures coming from the PWT. The base year for all prices is 2005, and hence note that the relative prices are equal to one in all countries in 2005.

\(^{14}\)The MCMC is also particularly convenient for computing standard errors in a set-up like the one we consider. For instance, if some of the sectoral shares within exports are close to zero, the inverse of the Jacobian of \( g^{v}(\Theta^{v}, t) \) will approach infinity, which makes the calculation of standard errors in a GMM framework unfeasible.

\(^{15}\)We start by estimating a model with \( \rho = 0 \) and with a linear version of the sectoral export and import shares. These assumptions allow us to estimate a linear version of the model using OLS. Then, using the OLS estimates as initial values, we allow \( \rho \) to be different from 0 and estimate the model using non-linear GMM. Finally, we use the GMM estimates and their estimated variances to set the initial values and the proposal distributions of the random-walk Metropolis-Hasting.
Finally, our estimation sample consists of 48 countries with data from 1950 to 2011. Our requirements for a country to make it into the sample are: (a) have all data since at least 1985, (b) not too small (population in 2005 > 4M), (c) not too poor (GDP per capita in 2005 > 5% of US), (d) not oil-based (oil rents < 10% of GDP).

5 Results

We start by presenting the estimation results and the implied sectoral intensity of investment and consumption goods. Next, we will show the implications of the different sectoral intensity of consumption and investment goods for selected development episodes, for the hump in manufacturing, and for the evolution of the relative price of investment goods.

5.1 Estimation results

The estimation of the model country by country generates a very good fit. Figure 5 plots the model-implied shares of agriculture (Panel a), services (Panel b), and manufactures (Panel c) against their data counterpart for all countries and periods together. The points sit in the 45 degree line and the variation in model-predicted shares explains most of the variation in the data. In particular, regressing the sectoral shares in the data against their model predictions gives intercepts close to zero, slopes close to one, and $R^2$ around 97% for the three sectors.\(^\text{16}\)

Our main finding from the estimation is that we recover a substantial asymmetry between investment and consumption goods. The first row in Table 3 reports the model-implied sectoral composition of each good when taking the average over all countries and years. We see that the share of manufactures in investment goods is 37 percentage points larger than in consumption goods.\(^\text{17}\) We can compare these estimates with the direct observation of sectoral shares in the WIOD. The second and third rows of Table 3 report the sectoral composition of both goods for the common countries and years in our estimation sample and in the WIOD, this is 25 countries in the period 1995 to 2011. We find that the mean of our estimates resemble the data in the WIOD reasonably well: the share of manufactures is 37.5 percentage points higher in investment than in consumption in the WIOD data, while this difference is 42.4 percentage points in our estimation. Note

\(^{16}\)The model fit country by country is also good: Table E.1 in Appendix E reports the fit country by country for each sector, while Panel (a) in Figures E.1-E.48 in the same Appendix E plots the actual and model-implied time series of the value added share of manufacturing for each country.

\(^{17}\)See Panel (d) in Figures E.1-E.48 of Appendix E for more details on the model-implied time series of the value added share of manufacturing within investment and consumption country by country.
that there is nothing in the estimation strategy that imposes this value, hence the data from the WIOD should serve as a validation of our estimates.

Finally, in Figure 6 we plot the evolution of the estimated share of manufactures within investment and consumption goods against the level of development, after filtering out cross-country differences in levels. We observe a mild hump both in consumption and investment, see Panel (c) and (d) respectively, although it is more clear for consumption. The estimated model also produces a larger hump of manufacturing in GDP, see Panel (b), which resembles very much the one in the data, see Panel (a). This is the same pattern we uncovered with a much reduced time dimension in the WIOD data in Figure 2. In addition, and not reported here, we also find a larger fall of agriculture and a larger increase of services within consumption than within investment as in the WIOD data, which validates our assumption of using a non-homothetic aggregator for consumption and a homothetic one for investment.
Table 3: Sectoral composition of investment and consumption goods.

<table>
<thead>
<tr>
<th></th>
<th>investment (x)</th>
<th>consumption (c)</th>
<th>difference (x - c)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a</td>
<td>m</td>
<td>s</td>
</tr>
<tr>
<td>Whole sample</td>
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<td></td>
<td></td>
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<tr>
<td>Estimates</td>
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<td>58.0</td>
<td>34.0</td>
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<td>WIOD sample</td>
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<tr>
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<tr>
<td>Data</td>
<td>3.1</td>
<td>53.0</td>
<td>43.9</td>
</tr>
</tbody>
</table>

Notes: The first row reports the average over all countries and years of the value added shares of investment and consumption goods estimated in the main sample. The second row reports the same statistics for the country and years for which data from WIOD is available. The third row reports the same statistics in the WIOD for the same country and years as row 2.

5.2 Development episodes

In order to quantify the importance of transitional dynamics in the evolution of sectoral composition of the economy we perform two decompositions as in Section 2.4. First, we use equation (24) to produce for every country counterfactual series for the open economy case in which only the intensive or extensive margins of structural change are active. Second, we use equation (22) to produce intensive and extensive margin counterfactual series for the closed economy with the same sectoral composition of consumption and investment from the main estimation.

In Panel (a) of Table 4 we report the 10 episodes where the increase in investment demand was more important for the process of industrialization, while in Panel (b) we report the 10 episodes where the fall in investment demand was more important for the process of deindustrialization. To define an “episode”, we select for every country an interval of years in which the investment rate changes substantially.

We find that the increase in the investment rate was an important driver of industrialization in the development process of South Korea, Malaysia, and Thailand until the early 90’s, of China and India since the early 50’s, of Japan and Taiwan until the early 70’s, and of Indonesia (1965-2011), Paraguay (1962-1980) and Vietnam (1987-2007). For this group of development episodes, the share of manufacturing increased on average by 18.6 per-

---

18 See Panel (b) in Figures E.1-E.48 of Appendix E for a country by country comparison of the estimated value added share of manufacturing against the counterfactuals.
Table 4: Increase in manufacturing for selected episodes

**Panel (a): Development episodes**

<table>
<thead>
<tr>
<th>Country</th>
<th>Years</th>
<th>Data</th>
<th>Open Economy</th>
<th>Closed Economy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First</td>
<td>Last</td>
<td>All</td>
<td>Int</td>
</tr>
<tr>
<td>South Korea</td>
<td>1959</td>
<td>1992</td>
<td>26.8</td>
<td>23.5</td>
</tr>
<tr>
<td>Malaysia</td>
<td>1970</td>
<td>1995</td>
<td>10.4</td>
<td>9.2</td>
</tr>
<tr>
<td>China</td>
<td>1952</td>
<td>2010</td>
<td>27.2</td>
<td>27.8</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1965</td>
<td>2011</td>
<td>32.7</td>
<td>27.1</td>
</tr>
<tr>
<td>Thailand</td>
<td>1951</td>
<td>1993</td>
<td>22.7</td>
<td>21.4</td>
</tr>
<tr>
<td>India</td>
<td>1950</td>
<td>2009</td>
<td>13.8</td>
<td>14.5</td>
</tr>
<tr>
<td>Japan</td>
<td>1953</td>
<td>1970</td>
<td>5.1</td>
<td>6.1</td>
</tr>
<tr>
<td>Vietnam</td>
<td>1987</td>
<td>2007</td>
<td>14.8</td>
<td>15.5</td>
</tr>
<tr>
<td>Paraguay</td>
<td>1962</td>
<td>1980</td>
<td>7.1</td>
<td>6.5</td>
</tr>
<tr>
<td>Taiwan</td>
<td>1961</td>
<td>1975</td>
<td>17.0</td>
<td>21.1</td>
</tr>
<tr>
<td>Average</td>
<td>18.6</td>
<td>18.1</td>
<td>7.6</td>
<td>10.5</td>
</tr>
</tbody>
</table>

**Panel (b): Deindustrialization episodes**

<table>
<thead>
<tr>
<th>Country</th>
<th>Years</th>
<th>Data</th>
<th>Open Economy</th>
<th>Closed Economy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First</td>
<td>Last</td>
<td>All</td>
<td>Int</td>
</tr>
<tr>
<td>Japan</td>
<td>1970</td>
<td>2011</td>
<td>-11.8</td>
<td>-11.8</td>
</tr>
<tr>
<td>Finland</td>
<td>1974</td>
<td>1995</td>
<td>-7.1</td>
<td>-6.6</td>
</tr>
<tr>
<td>Germany</td>
<td>1970</td>
<td>2010</td>
<td>-20.0</td>
<td>-15.4</td>
</tr>
<tr>
<td>Singapore</td>
<td>1982</td>
<td>2004</td>
<td>-4.5</td>
<td>-3.7</td>
</tr>
<tr>
<td>Argentina</td>
<td>1977</td>
<td>2001</td>
<td>-14.0</td>
<td>-12.9</td>
</tr>
<tr>
<td>Belgium</td>
<td>1970</td>
<td>1985</td>
<td>-9.8</td>
<td>-13.4</td>
</tr>
<tr>
<td>Philippines</td>
<td>1978</td>
<td>2008</td>
<td>-4.7</td>
<td>-3.7</td>
</tr>
<tr>
<td>Sweden</td>
<td>1970</td>
<td>1996</td>
<td>-7.1</td>
<td>-7.5</td>
</tr>
<tr>
<td>Denmark</td>
<td>1971</td>
<td>1993</td>
<td>-6.0</td>
<td>-6.1</td>
</tr>
<tr>
<td>Austria</td>
<td>1971</td>
<td>2010</td>
<td>-9.8</td>
<td>-11.6</td>
</tr>
<tr>
<td>Average</td>
<td>-9.5</td>
<td>-9.3</td>
<td>-5.6</td>
<td>-3.6</td>
</tr>
</tbody>
</table>

Notes: This Table reports the increase in the share of manufacturing for several model-predicted series for the given country and period. Column “Data” refers to the increase in the data, while columns under the labels “Open Economy” and “Closed Economy” refer to the increases in the models. Column “All” refers to the model prediction, while columns “Int” and “Ext” refer to the intensive and extensive margin counterfactuals.
Figure 6: Manufacturing share

Notes. Share of manufacturing within GDP —data Panel (a), model Panel (b)— within investment —Panel (c)— and consumption —Panel (d)—, all countries and periods pooled together, each color and shape represents data from a different country. The black lines represent the projections on a quadratic polynomial of log GDP per capita in constant international dollars. Series have been filtered out from country fixed effects.

...percentage points, of which the estimated open economy model reproduces 18.1 percentage points. Half of the increase (9.0 percentage points) is accounted for by the increase in the investment rate (the extensive margin of the closed economy), while only 1/5 (3.4 percentage points) by the increase in manufacturing within investment and within consumption (the intensive margin of the closed economy). Overall, the closed economy explains an increase of 13.1 percentage points, leaving less than 1/3 to be explained by the increase in the level and composition of exports.

In the case of South Korea, for example, out of the 26.8 percentage points of increase in the share of manufacturing between 1959 and 1992. Our estimated model accounts for 23.5 points increase, of which 3.5 percentage points come from the intensive margin and 19.5 come from the extensive margin. When restricting the analysis to the closed economy case our model produces an increase in industrial value added of 19.3 percentage points, 1.2 from the intensive margin and 16.3 from the extensive margin. We note that
the closed economy exercise under-predicts the increase in manufacturing by 4 percentage points, which is due to both the intensive and extensive margins. The larger increase of the intensive margin in the open economy (3.5 percentage points vs 1.2 in the closed economy) reflects that there was a faster increase of manufactures within exports than within domestic demand. The larger increase of the extensive margin in the open economy (19.5 percentage points vs 16.3 in the closed economy) reflects a large increase in exports (from 2 to 25 percent of GDP) and the fact that in South Korea exports were more intensive in value added from manufacturing than domestic demand. But all in all, the sustained increase in the investment rate in South Korea over this period was a fundamental driver of its industrialization process.\footnote{Our results show that exports played a significant but not essential role in the industrialization process of South Korea, which differs from the findings by Uy, Yi, and Zhang (2014). The key of our novel result is to take into account the different composition of investment and consumption goods together with the large increase in the investment rate over the period.}

Next, we also find investment to be an important driver of structural change in many countries that went through a deindustrialization process in the 70’s or the 80’s. In particular, this was the case in Japan, Finland, Germany, Sweden, Denmark, and Austria since the early 70’s or Singapore, Philippines and Argentina since the late 70’s or early 80’s. On average, these countries saw a decline in manufactures of 9.5 percentage points, of which 2/3 (6.2 percentage points) come from the decline of the investment rate, 1/4 (2.6 percentage points) from the decline of manufacturing within domestic demand, and the rest from changes in the level and composition of exports.

For a particular example we can focus on Germany. The share of manufacturing declined by 20 percentage points between 1970 and 2010. Our estimated model predicts a somewhat smaller decline of 15.4 percentage points, of which 1/3 comes from the extensive margin (4.6 percentage points) and 2/3 come from the intensive margin (10 percentage points). When looking at the closed economy, there is no change coming from the intensive margin and a large decline in the extensive margin (7.6 percentage points). The lack of decline of the intensive margin in the closed economy (vs the 10 point decline in the open economy) reflects that the share of manufacturing within exports declined faster than within domestic demand. The larger decline of the extensive margin in the closed economy (7.6 percentage points vs 4.6 in the open economy) reflects the large increase in exports (from 14 to 42 percent of GDP) and the fact that exports in Germany are more intense in manufacturing than domestic demand.\footnote{The fast decline of manufacturing within German exports may be surprising, but it is consistent with the increasing fragmentation of production across borders. Using IO tables, Timmer, Los, Stehrer, and de Vries (2013) show that the manufactured goods exported by Germany contain an increasing share of value added from the German service sector as the manufacturing value added of those goods is increasingly}
### Table 5: Decomposition of structural change.

<table>
<thead>
<tr>
<th>Data</th>
<th>Open economy</th>
<th>Closed economy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
<td>Int</td>
</tr>
<tr>
<td>Agriculture</td>
<td>-44.4</td>
<td>-40.0</td>
</tr>
<tr>
<td>Δ Industry</td>
<td>24.7</td>
<td>22.2</td>
</tr>
<tr>
<td>▽ Industry</td>
<td>-20.5</td>
<td>-19.5</td>
</tr>
<tr>
<td>log y at peak</td>
<td>9.1</td>
<td>9.1</td>
</tr>
<tr>
<td>Services</td>
<td>40.1</td>
<td>37.3</td>
</tr>
</tbody>
</table>

Notes: rows show the change in percentage points of the corresponding sectoral share as economies develop. Industry is divided in the increasing (Δ) and decreasing (▽) parts and we also report the income level at which the peak happens for each series.

#### 5.3 The hump in manufacturing

In the previous Section we showed several episodes where the change in the investment rate was quantitatively important for the change in the sectoral composition of the economy. In this Section we pool all countries and years together to measure the importance of the change in the investment rate in accounting for the hump in manufacturing with development.

In Table 5 we report the average increase in manufacturing in the first half of the hump, 24.7 percentage points, and its decline in the second half, 20.5 percentage points. As already seen in Panel (b) of Figure 6, our estimated model reproduces well these changes (22.2 and 19.5). We find that for the increasing part, more than half comes from the extensive margin (13.3), while for the decreasing part most action comes from the intensive margin (18.6). Our closed economy reproduces more than half of these changes (12.2 increase, 13.0 decline), with the extensive margin accounting for more than half of the increase (7.8 percentage points) and a substantial part of the decline (4.1 percentage points). Note that for the increasing part of the hump, both the intensive and extensive margins of the closed economy under-predict the actual increases in the open economy, which means that at initial stages of development the increase of manufacturing within exports is larger than within domestic demand and that exports are more intensive in value added from manufacturing than domestic demand. This average pattern is analogous to the case of South Korea described above. For the decreasing part of the hump, however, the closed economy only under-predicts the open economy in the intensive margin and it produced abroad.
slightly over-predicts the decline in the extensive margin. This means that at later stages of development the fall of manufacturing within exports is larger than within domestic demand and that the average composition of exports is only slightly more intense in manufactures than domestic demand. This general pattern is not too different from the one in Germany described above. As we discussed in the Introduction, existing closed economy models of structural change have problems in generating a hump of manufacturing under balanced growth path. Our results here show the importance of transitional dynamics and exports in accounting for the hump. In particular, note that the structural change within consumption and within investment emphasized by these models (the intensive margin of the closed economy) only accounts for 1/5 of the increase and 1/2 of the decline of manufacturing with development.

Finally, in Table 5 we also reproduce the same decompositions for agriculture and services. Not surprisingly, the extensive margin is of less importance in these cases as the trend decline in agriculture and the trend increase in services are hard to relate to the hump in investment.

5.4 Relative prices

Our findings have important implications for the evolution of the relative price of investment. Because investment goods are more intensive in value added from the industrial sector than consumption goods, a fall in the relative price of manufacturing should yield a decline in the relative price of investment. In particular, looking at equations (12) and (15) for $p_{ct}$ and $p_{xt}$ we see that in the empirically relevant case of $\rho < 0$ prices of both investment and consumption goods decline with the fall in sectoral price $p_{it}$, but if investment is more intensive than consumption in the value added of sector $i$ then this will translate into a fall in the relative price of investment goods.

In this Section we compare the evolution over time of the relative price of investment in the data to the one implied by our model. To do so, we feed the sectoral relative prices in equations (12) and (15) and compare the implied evolution in the relative price of investment with the one measured in the data. We use investment price data from two different sources. Our first data source is the PWT (Mark, 9.0), where prices of investment and consumption are provided for many years and countries. These prices are reported at current PPP rates. This is not convenient for us, since the data counterparts of the prices in the model should be the prices faced by domestic agents. We follow Restuccia and Urrutia (2001) and Karabarbounis and Neiman (2014) to convert the prices reported
Figure 7: Evolution of the relative price of investment

(a): year fixed effects (PWT vs model)       (b): year fixed effects (WDI vs model)

Notes. The blue line shows the estimated year fixed effects of regressing the log relative prices of investment in the data against country and year fixed effects. The red line shows the equivalent fixed effects from a similar regression using the model-implied relative prices for the same countries and years. Panel (a) uses the PWT data, while panel (b) the WDI data. In all cases, the log fixed effects are normalised to 0 in 1980.

by the PWT into prices measured in local currency units. Our second data source is the WDI, which provides time series of investment and consumption both at current and constant prices for a large number of countries. To construct series for the relative price of investment, we simply divide the implicit price deflators of investment and consumption.

Figure 7 shows the evolution of the relative price of investment as measured in the data and in our model. In particular, we follow Karabarbounis and Neiman (2014) and report the year fixed effects that are estimated in a pooled regression of the relative price of investment against country and year fixed effects. Panel (a) compares these year fixed effects from a regression using the PWT to their model counterparts from a regression using data generated by our model, for the same set of countries and years. Panel (b) does the same but using the WDI as the data source. The model-generated relative prices come from feeding sectoral prices in equations (12) and (15). We find that the decline of the relative price of investment predicted by our model is around 1/4 of the one observed by use of the PWT and 1/2 of the one observed by use of WDI.

The relative decline of the price of investment has several macroeconomic implications. Following Greenwood, Hercowitz, and Krusell (1997), one way to incorporate this pattern in macro models is by thinking of an acceleration in investment-specific technical progress. We show that between 1/4 and 1/2 of the decline of the relative price of investment goods during the past decades can be accounted for by the relative decline in

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21 See appendix C for more details.

the price of manufactures and the fact that investment goods are more intensive in manufactures than consumption goods. In other words, the relative increase in productivity of manufacturing sector broadly defined accounts for a big part of what is been labelled as investment-specific technical change. It is quite likely to think that a less coarse sectoral classification could help us understand better the origins of investment-specific technical change.

6 Conclusion

The set of goods that an economy uses for final consumption is different from the set of goods that an economy uses for final investment. In this paper we have provided novel empirical evidence that investment goods contain a much larger share of value added from industrial sectors than consumption goods do. This finding has first-order macroeconomic implications that have been so far ignored.

In particular, several countries have recently experienced long periods of industrialization or deindustrialization in which investment rates were far from constant. At the same time, these countries experienced a strong pattern of structural transformation. Our paper takes an important first step in relating these two facts. The mechanism that we propose is simple: if manufacturing goods are more important for investment than for consumption, then an increase in the investment rate should mechanically shift the composition of the economy towards manufacturing. The plausibility of this mechanism gets reinforced by an additional observation: the size of the well documented hump shape of manufacturing value added share with development seems to be absent when looking at consumption and investment separately.

Our counterfactual exercises show that the extensive margin of structural change is quantitatively important for several development and deindustrialization episodes. It also has some bite to explain the observed hump of manufacturing with development. And it can rationalize part of the decline in the relative price of investment goods.

Our exercise does not attempt to explain the behaviour of investment rate dynamics outside the balanced growth path. There is a limited number of papers whose main aim is to provide theories able to reproduce the observed evolution of saving rates in some countries. One example is Christiano (1989), who shows quantitatively that the Neoclassical growth model – with Cobb-Douglas technology and Stone-Geary preferences with the parameter that governs the consumption subsistence level indexed to productivity—can generate the observed hump-shape in the savings rate in Japan during the 1950-1980 period. Another example is Antràs (2001), who analytically shows that the Neoclassical
growth model under high complementarity between capital and labor is also able to reproduce a hump shape in savings rate that resembles the one observed for OECD countries between 1950 and 1980. A next step in this research agenda is to provide a framework able to match quantitatively the observed hump in investment alongside the well documented patterns of structural change.
References


Timmer, M., G. J. de Vries, and K. de Vries (2014): “Patterns of Structural Change in Developing Countries,” GGDC Research memorandum 149.


Appendix A: Data sources and sector definitions

We use four different data sources: the three described in this Section and the WIOD described in Appendix B.

A.1 World Development Indicators (WDI)

We use the WDI database to obtain value added shares at current and at constant prices for our three sectors. The WDI divides the economy in 3 sectors: Agriculture (ISIC Rev 3.1 A and B), Industry (C to F), and Services (G to Q), which are the one that we use.\(^{23}\)

In addition, we also use the variables for population and oil rents as a share of GDP in order to drop countries that are too small in terms of population and countries whose GDP is largely affected by oil extraction.

A.2 Groningen 10-Sector Database (G10S)

We use the G10S database to obtain value added shares at current and at constant prices for our three sectors. The G10S divides the economy in 10 industries, which we aggregate into our three main sectors as described in Table A.1.

### Table A.1: G10S industry classification

<table>
<thead>
<tr>
<th>Industry</th>
<th>Assigned Sector</th>
<th>ISIC 3.1 Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>Agr</td>
<td>A,B</td>
<td>Agriculture, Hunting, Forestry and Fishing</td>
</tr>
<tr>
<td>Mining</td>
<td>Ind</td>
<td>C</td>
<td>Mining and Quarrying</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>Ind</td>
<td>D</td>
<td>Manufacturing</td>
</tr>
<tr>
<td>Utilities</td>
<td>Ind</td>
<td>E</td>
<td>Electricity, Gas and Water Supply</td>
</tr>
<tr>
<td>Construction</td>
<td>Ind</td>
<td>F</td>
<td>Construction</td>
</tr>
<tr>
<td>Trade Services</td>
<td>Ser</td>
<td>G,H</td>
<td>Wholesale and Retail Trade; Repair of Motor Vehicles, Motorcycles and Personal and Household Goods; Hotels and Restaurants</td>
</tr>
<tr>
<td>Transport Services</td>
<td>Ser</td>
<td>I</td>
<td>Transport, Storage and Communications</td>
</tr>
<tr>
<td>Business Services</td>
<td>Ser</td>
<td>J,K</td>
<td>Financial Intermediation, Renting and Business Activities (excluding owner occupied rents)</td>
</tr>
<tr>
<td>Government Services</td>
<td>Ser</td>
<td>L,M,N</td>
<td>Public Administration and Defense, Education, Health and Social Work</td>
</tr>
<tr>
<td>Personal Services</td>
<td>Ser</td>
<td>O,P</td>
<td>Other Community, Social and Personal Service Activities, Activities of Private Households</td>
</tr>
</tbody>
</table>

\(^{23}\)For some countries and years it also provides a breakdown of the Industry category with the Manufacturing sector (D) separately.
A.3 Penn World Tables (PWT)

We use the 9.0 version of the PWT to obtain the series for consumption, investment, export, and import shares of GDP in LCU at current prices. We also use the series for GDP per capita in constant LCU and the per capita GDP in constant international dollars. In addition, we also use investment and consumption price data as described in Appendix C.

Appendix B: The World Input-Output tables

In this section we provide more details on how we use the 2013 Release of the World Input-Output Database (WIOD) to construct some of the variables that we use in the paper. In particular, we explain (a) how we construct sectoral value added shares for consumption, investment, and exports for all countries and years, (b) how we aggregate from these sectoral value added shares by type of final good to sectoral value added shares of GDP, and (c) how to approximate the aggregation of sectoral value added shares without IO data.

B.1 Sectoral value added shares in consumption, investment, and exports

The 2013 Release of the WIOD provides national IO tables disaggregated into 35 industries for 40 countries and 17 years (the period 1995-2011). We aggregate the 35 different industries into agriculture, industry, and services according to table B.2. Total production in each industry is either purchased by domestic industries (intermediate expenditure) or by final users (final expenditure), which include domestic final uses and exports. To measure how much domestic value added from each sector goes to each final use we have to follow three steps, which we explain in the next three paragraphs closely following the Appendix in Herrendorf, Rogerson, and Valentinyi (2013).

First, we build the \( (n \times 1) \) vectors \( e_X, e_C, e_E \) with the final expenditure in consumption (final consumption by households plus final consumption by non-profit organisations serving households plus final consumption by government), investment (gross fixed capital formation plus changes in inventories and valuables), and exports coming from each of the \( n \) sectors, where \( n = 3 \) in our case.

Second, we build the \( (n \times n) \) Total Requirement (TR) matrix linking sectoral expenditure to sectoral production. In particular, the IO tables provided by the WIOD assume that each industry \( j \) produces only one commodity, and that each commodity \( i \) is used in only one industry.\(^{24}\) Let \( A \) denote the \( (n \times n) \) transaction matrix, with entry \( ij \) showing the dollar amount of commodity \( i \) that industry \( j \) uses per dollar of output it produces. Let \( e \) denote the \( (n \times 1) \) final expenditure vector, where entry \( j \) contains the dollar amount of final expenditure coming from industry \( j \). Note that \( e = e_X + e_C + e_E \). Let \( g \) denote the \( (n \times 1) \) industry gross output vector, with entry \( j \) containing the total output in dollar amounts produced in industry \( j \). Finally, let \( q \) denote the \( (n \times 1) \) commodity gross output

\(^{24}\)Notice that this structure is similar to the IO provided by the BEA prior to 1972.
The following identities link these matrices three matrices with the \( (TR) \) matrix:

\[
\begin{align*}
q &= Ag + e \\
q &= g
\end{align*}
\]

We first get rid of \( q \) by using the second identity. We then solve for \( g \):

\[
g = (I - A)^{-1} e \tag{B.1}
\]

where \( TR = (I - A)^{-1} \) is the total requirement matrix. Entry \( ji \) shows the dollar value of the production of industry \( j \) that is required, both directly and indirectly, to deliver one dollar of the domestically produced commodity \( i \) to final uses. Note that in this matrix rows are associated with industries and columns with commodities.

\[
\begin{align*}
VA_X &= \langle v \rangle TR e_I \\
VA_C &= \langle v \rangle TR e_C \\
VA_E &= \langle v \rangle TR e_X
\end{align*} \tag{B.2}
\]

where the \( (n \times n) \) matrix \( \langle v \rangle \) is a diagonal matrix with the vector \( v \) in its diagonal. \( VA_X, VA_C, \) and \( VA_E \) contain the sectoral composition of value added used for investment, consumption, and export goods. To compute the share of each sector within investment, consumption, and exports, we simply divide each element by the sum of all elements in each vector,

\[
\begin{align*}
\frac{VA_x}{VA} &= \frac{VA_X (i)}{\sum_{i=1}^{n} VA_X (i)} \\
\frac{VA_c}{VA} &= \frac{VA_C (i)}{\sum_{i=1}^{n} VA_C (i)} \\
\frac{VA_e}{VA} &= \frac{VA_E (i)}{\sum_{i=1}^{n} VA_E (i)} \tag{B.3}
\end{align*}
\]

\section*{B.2 Aggregation}

Let's start from 4 national accounts identities. First, from the expenditure side GDP can be obtained as the sum of expenditure in investment \( X \), consumption \( C \), exports \( E \) minus imports \( M \):

\[
GDP = X + C + E - M \tag{B.4}
\]

Second, from the production side GDP can be obtained as the sum of value added \( VA_i \) produced in different sectors \( i \),

\[
GDP = \sum_i VA_i \tag{B.5}
\]
Third, the value added of sector \( i \) can be expressed as:

\[
VA_i = VA^x_i + VA^c_i + VA^e_i
\]  

(B.6)

where \( VA^x_i \), \( VA^c_i \), and \( VA^e_i \) are the valued added produced in sector \( i \) used for final investment, final consumption, and final exports respectively and are obtained from equation (B.2) above. Note that summing up equation (B.6) across sectors gives us:

\[
GDP = VA^x + VA^c + VA^e
\]  

(B.7)

And fourth, the expenditure in investment \( X \) (or analogously consumption \( C \) and exports \( E \)) equals the sum of value added domestically produced that is used for investment \( VA^x \) and the imported value added that is used for investment (either directly or indirectly through intermediate goods), \( M^x \):

\[
\begin{align*}
X &= VA^x + M^x \quad \text{(B.8)} \\
C &= VA^c + M^c \quad \text{(B.9)} \\
E &= VA^e + M^e \quad \text{(B.10)}
\end{align*}
\]

Note that summing equations (B.8)-(B.10) gives us equation (B.4) as \( M = M^x + M^c + M^e \).

With these elements in place, note that the value added share of sector \( i \) in GDP can be expressed as:

\[
\frac{VA_i}{\text{GDP}} = \left( \frac{VA^x}{\text{GDP}} \right) \left( \frac{VA^x_i}{VA^x} \right) + \left( \frac{VA^c}{\text{GDP}} \right) \left( \frac{VA^c_i}{VA^c} \right) + \left( \frac{VA^e}{\text{GDP}} \right) \left( \frac{VA^e_i}{VA^e} \right)
\]  

(B.11)

That is, the value added share of sector \( i \) in GDP is a weighted average of the value added share of sector \( i \) within investment \( \frac{VA^x_i}{VA^x} \), consumption \( \frac{VA^c_i}{VA^c} \), and exports \( \frac{VA^e_i}{VA^e} \). These terms are the ones we have built in Appendix B.1 and that we describe in Table 1 and Panel (a), (c), and (e) of Figure 1. The weights are the share of domestic value added that is used for investment \( \frac{VA^x_i}{\text{GDP}} \), for consumption \( \frac{VA^c_i}{\text{GDP}} \), and for exports \( \frac{VA^e_i}{\text{GDP}} \). Note that these weights are not the investment \( \frac{X}{\text{GDP}} \), consumption \( \frac{C}{\text{GDP}} \), and export \( \frac{E}{\text{GDP}} \) rates as commonly measured in National Accounts because not all the expenditure in final investment, final consumption, and final exports comes from domestically produced value added. In particular,

\[
\begin{align*}
\frac{VA^x}{\text{GDP}} &= \left( \frac{X}{\text{GDP}} \right) \left( \frac{VA^x}{X} \right) \\
\frac{VA^c}{\text{GDP}} &= \left( \frac{C}{\text{GDP}} \right) \left( \frac{VA^c}{C} \right) \\
\frac{VA^e}{\text{GDP}} &= \left( \frac{E}{\text{GDP}} \right) \left( \frac{VA^e}{E} \right)
\end{align*}
\]

where the terms \( \frac{VA^x}{X} \), \( \frac{VA^c}{C} \), \( \frac{VA^e}{E} \) denote the fraction of total expenditure in investment, consumption, and exports that is actually produced domestically, and which according to equations (B.8)-(B.10) must be weakly smaller than 1. Finally, note that in a closed
economy the terms $\frac{VA^x}{X}$, $\frac{VA^c}{C}$, $\frac{VA^e}{E}$ will need to be one by construction and hence equation (B.11) would become,

$$\frac{VA_i}{GDP} = \left( \frac{X}{GDP} \right) \left( \frac{VA^x}{VA^x} \right) + \left( \frac{C}{GDP} \right) \left( \frac{VA^c}{VA^c} \right)$$

(B.12)

Equation (B.12) corresponds to equation (17) in the model.

### B.3 Approximation

In order to perform decompositions of extensive and intensive margin structural change with equation (B.11) one needs IO tables for both the extensive and intensive margin terms. We can get an approximation to equation (B.11) that is less demanding in terms of data. Note that using equation (B.8) we can rewrite the term $\frac{VA^x}{X}$ as

$$\frac{VA^x}{X} = \left( \frac{VA^x + M^x}{VA^x} \right)^{-1} = \left[ 1 + \frac{M}{GDP} \frac{M^x/M}{VA^x/GDP} \right]^{-1}$$

(B.13)

and analogous expressions obtain for $\frac{VA^c}{C}$ and $\frac{VA^e}{E}$. Note that if

$$\frac{M^x/M}{VA^x/GDP} = \frac{M^c/M}{VA^c/GDP} = \frac{M^e/M}{VA^e/GDP} = 1$$

then equation (B.11) can be written as,

$$\frac{VA_i}{GDP} = \left[ 1 + \frac{M}{GDP} \right]^{-1} \left[ \left( \frac{X}{GDP} \right) \left( \frac{VA^x_i}{VA^x} \right) + \left( \frac{C}{GDP} \right) \left( \frac{VA^c_i}{VA^c} \right) + \left( \frac{E}{GDP} \right) \left( \frac{VA^e_i}{VA^e} \right) \right]$$

(B.14)

or

$$\frac{VA_i}{GDP} = \left( \frac{X}{GDP + M} \right) \left( \frac{VA^x_i}{VA^x} \right) + \left( \frac{C}{GDP + M} \right) \left( \frac{VA^c_i}{VA^c} \right) + \left( \frac{E}{GDP + M} \right) \left( \frac{VA^e_i}{VA^e} \right)$$

(B.15)

with this approximation one can estimate the intensive margin terms as we do in Section 4 and use national accounts to obtain the extensive margin terms, hence no IO data is needed.

The question here is: how good is this approximation? To answer this question we compute the approximated value added shares for each sector, country and year in the WIOD using equation (B.14) and compare them to the actual ones. In Table B.1 we provide a few statistics to compare the actual with the approximated series pooling all countries and years of data. Panel (a) shows that both the mean and dispersion of the actual and approximated sectoral shares are very similar. It also shows that the correlation between the actual and approximated series are over 0.99 in all three sectors, both when pooling all the data and when controlling for country fixed effects. Panel (b) reports the results of regressing the actual shares against a polynomial of log GDP and country fixed
Table B.1: Sectoral composition: data vs. approximation

<table>
<thead>
<tr>
<th></th>
<th>Agr Data</th>
<th>Agr Appr</th>
<th>Ind Data</th>
<th>Ind Appr</th>
<th>Ser Data</th>
<th>Ser Appr</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel (a): Statistics</strong></td>
<td></td>
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<td>4.8</td>
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<td>4.6</td>
<td>6.7</td>
<td>6.7</td>
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<td>0.96</td>
<td>0.998</td>
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<td>0.995</td>
<td></td>
</tr>
<tr>
<td>corr (fe)</td>
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<td>0.995</td>
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<tr>
<td><strong>Panel (b): Regression</strong></td>
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<td>-26.6</td>
<td>40.6</td>
<td>42.0</td>
<td>-14.9</td>
<td>-15.3</td>
</tr>
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<td>1.1</td>
<td>-2.3</td>
<td>-2.4</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>R² (%)</td>
<td>60.3</td>
<td>60.4</td>
<td>19.4</td>
<td>18.8</td>
<td>45.9</td>
<td>45.1</td>
</tr>
</tbody>
</table>

Notes: Panel (a) reports mean, standard deviation, and correlation of the actual and approximated sectoral shares pooling all countries and years. It also provides the correlation of the differences with respect to country means to control for country fixed effects. Panel (b) regresses the sectoral shares, data and approximation, against country fixed effects, log GDP and log GDP squared. The coefficients are all significant at the standard 1% significance level and the R² corresponds to the regression of differences with respect to country means.

...with the R² partialling out the country fixed effects.25 Again, we see that the variation of the actual and approximated series with the level of development are very similar.

---

25 The regressions with the actual data are the ones used to construct the trends in Panel (b), (d), and (f) of Figure 1 in the paper.
<table>
<thead>
<tr>
<th>Industry</th>
<th>Assigned Sector (s)</th>
<th>Industry (j) Code</th>
<th>IO position</th>
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<tbody>
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<td>Agriculture, Hunting, Forestry and Fishing</td>
<td>Agriculture</td>
<td>AtB</td>
<td>c1</td>
</tr>
<tr>
<td>Mining and Quarrying</td>
<td>Industry</td>
<td>C</td>
<td>c2</td>
</tr>
<tr>
<td>Food, Beverages and Tobacco</td>
<td>Industry</td>
<td>15t16</td>
<td>c3</td>
</tr>
<tr>
<td>Textiles and Textile Products</td>
<td>Industry</td>
<td>17t18</td>
<td>c4</td>
</tr>
<tr>
<td>Leather, Leather and Footwear</td>
<td>Industry</td>
<td>19</td>
<td>c5</td>
</tr>
<tr>
<td>Wood and Products of Wood and Cork</td>
<td>Industry</td>
<td>20</td>
<td>c6</td>
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<tr>
<td>Pulp, Paper, Paper, Printing and Publishing</td>
<td>Industry</td>
<td>21t22</td>
<td>c7</td>
</tr>
<tr>
<td>Coke, Refined Petroleum and Nuclear Fuel</td>
<td>Industry</td>
<td>23</td>
<td>c8</td>
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<tr>
<td>Chemicals and Chemical Products</td>
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<td>c9</td>
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<tr>
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<tr>
<td>Basic Metals and Fabricated Metal</td>
<td>Industry</td>
<td>27t28</td>
<td>c12</td>
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<tr>
<td>Machinery, Nec</td>
<td>Industry</td>
<td>29</td>
<td>c13</td>
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<tr>
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<td>30t33</td>
<td>c14</td>
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<td>Transport Equipment</td>
<td>Industry</td>
<td>34t35</td>
<td>c15</td>
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<td>36t37</td>
<td>c16</td>
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<td>Industry</td>
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<td>c20</td>
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<td>Motorcycles; Repair of Household Goods</td>
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<td>c25</td>
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<td>Other Supporting and Auxiliary</td>
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<td>c27</td>
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<td>Post and Telecommunications</td>
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<td>Renting of M&amp;Eq and Other Business Activities</td>
<td>Services</td>
<td>71t74</td>
<td>c30</td>
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<td>Public Admin and Defense, Compulsary Social Security</td>
<td>Services</td>
<td>L</td>
<td>c31</td>
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<td>Education</td>
<td>Services</td>
<td>M</td>
<td>c32</td>
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<tr>
<td>Health and Social Work</td>
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<td>c33</td>
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<td>Other Community, Social and Personal Services</td>
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<td>c34</td>
</tr>
<tr>
<td>Private Households with Employed Persons</td>
<td>Services</td>
<td>P</td>
<td>c35</td>
</tr>
</tbody>
</table>
Appendix C: Building relative price data

In this section we explain in detail how we construct the data series of the relative price of investment used in section 5.4.

**PWT:** Our first source of data is the Penn World Tables (PWT, Mark 9.0), which contains the price of investment ("Price Level of capital formation") and consumption ("Price Level of household consumption") at yearly frequency for more than 150 countries over the 1950-2010 period.\(^{26}\) The investment and consumption prices in PWT are reported at current purchasing power parity (PPP) rates. This is done by using individual good prices using the same basket of goods in all countries for consumption and investment, and dividing the expenditure in these goods in each country by the expenditure measured at international prices. For instance, the price of investment reported for Spain at a given point in time would be:

\[
P_{x,pwt}^{ESP} = \frac{p_{x,\$}^{*}}{p_{x,\$}^{*}} \tag{C.1}
\]

where \(p_{x,\$}^{*}\) measures the international price of investment.\(^{27}\) Notice that this is not our object of interest, since we are after the price of investment faced by domestic agents. We follow three steps to convert these prices into our objects of interest.\(^{28}\) First, we divide the price of investment by the price of consumption for each country-year. Following our previous example:

\[
\text{Rel} \left( P_{x,pwt}^{ESP} \right) = \frac{P_{x,pwt}^{ESP}}{P_{c,pwt}^{ESP}} = \frac{p_{x,\$}^{*}}{p_{c,\$}^{*}} \tag{C.2}
\]

Second, in order to get rid of international prices, we divide each country’s relative price of investment by its counterpart for the US. This is:

\[
\frac{\text{Rel} \left( P_{x,pwt}^{ESP} \right)}{\text{Rel} \left( P_{USA,pwt}^{ESP} \right)} = \frac{\left( \frac{p_{x,\$}^{*}}{p_{c,\$}^{*}} \right)}{\left( \frac{p_{x,\$}^{*}}{p_{c,\$}^{*}} \right)} \tag{C.3}
\]

Notice that this expression does not depend on local currency nor on international prices. Finally, in order to get rid of the relative price of investment for the USA, we multiply this expression by the ratio of investment and consumption deflator provided by the BEA:

\[
\left( \frac{\text{Rel} \left( P_{x,pwt}^{ESP} \right)}{\text{Rel} \left( P_{USA,pwt}^{ESP} \right)} \right) \times \left( \frac{P_{BREA}^{BEA}}{P_{BREA}^{BEA}} \right) = \frac{p_{x,\$}^{ESP}}{p_{c,\$}^{ESP}} \tag{C.4}
\]

\(^{26}\)The panel of countries is very unbalanced. The prices are reported over the entire period for only 55 countries.

\(^{27}\)All price levels in PWT 8.1 are reported relative to the price level of 2005 USA GDP. To simplify notation, we do not include it in any of our expressions.

\(^{28}\)We borrow step one and two from Restuccia and Urrutia (2001) and step three from Karabarbounis and Neiman (2014).
which finally gives us the relative price of investment goods as faced by domestic agents.

**WDI:** Our second source of data is the WDI. This dataset contains time series for nominal and real investment ("Gross fixed capital formation, current LCU" and "Gross fixed capital formation, constant LCU") and for nominal and real consumption ("Household final consumption expenditure, current LCU" and "Household final consumption expenditure, constant LCU") for the 1960-2015 period. We construct yearly price deflators by dividing the series reported at current prices by the series reported at constant prices. We then divide the investment price deflator by the consumption deflator to obtain our measure for the relative price of investment.

**Appendix D: Closing the model with identical Cobb-Douglas production functions**

There is a representative firm in each sector $i$ combining capital $k_{it}$ and labor $l_{it}$ to produce the amount $y_{it}$ of the final good $i$. The production functions are Cobb-Douglas with equal capital shares and different technology level $B_{it}$,

$$y_{it} = k_{it}^\alpha (B_{it}l_{it})^{1-\alpha}$$

The objective function of each firm is given by,

$$\max_{k_{it},l_{it}} \{p_{it}y_{it} - r_{t}k_{it} - w_{t}l_{it}\}$$

Leading to the standard FOC,

$$r_{t} = \alpha p_{it} \left( \frac{k_{it}}{B_{it}l_{it}} \right)^{\alpha-1}$$

$$w_{t} = (1-\alpha) B_{it} p_{it} \left( \frac{k_{it}}{B_{it}l_{it}} \right)^{\alpha}$$

which has the implications that,

$$k_{t} = \frac{k_{it}}{l_{it}} = \frac{k_{jt}}{l_{jt}} = \frac{\alpha}{1-\alpha} \frac{w_{t}}{r_{t}}$$

(D.1)

and that

$$\frac{p_{it}}{p_{jt}} = \left( \frac{B_{jt}}{B_{it}} \right)^{1-\alpha}$$

(D.2)

Hence, we can write the interest rate and total output $y_{t}$ as a function of capital per capita in the economy,

$$r_{t} = \alpha p_{it} B_{it}^{1-\alpha} k_{t}^{\alpha-1}$$

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and
\[ y_t = \sum_{j=a,m,s} p_{jt} y_{jt} = p_{it} B_{it}^{1-\alpha} k_t^\alpha \]  

Finally, let’s define average productivity in consumption \( B_{ct} \) and in investment \( B_{xt} \) as follows,
\[ B_{ct} \equiv \left[ \sum_{i=a,m,s} \theta_i^c B_{it}^{1-\alpha} \left( \frac{\rho}{\rho-1} \right)^{1-\alpha} \right] \]
\[ B_{xt} \equiv \left[ \sum_{i=a,m,s} \theta_i^x B_{it}^{1-\alpha} \left( \frac{\rho}{\rho-1} \right)^{1-\alpha} \right] \]

Using the definitions of \( p_{ct} \) and \( p_{xt} \) in equations (12) and (15) we can write,
\[ \frac{p_{it}}{p_{ct}} = \left( \frac{B_{it}}{B_{it}^{1-\alpha}} \right)^{1-\alpha} \quad \text{and} \quad \frac{p_{it}}{p_{xt}} = \chi_t \left( \frac{B_{xt}}{B_{xt}^{1-\alpha}} \right)^{1-\alpha} \]  

and also
\[ \frac{p_{xt}}{p_{ct}} = \frac{1}{\chi_t} \left( \frac{B_{xt}}{B_{xt}^{1-\alpha}} \right)^{1-\alpha} \]  

As a final note, the growth rates of the productivity terms \( B_{ct} \) and \( B_{xt} \) can be expressed as,
\[ \frac{B_{ct+1}}{B_{ct}} = \left[ \sum_{i=a,m,s} \theta_i^c \left( \frac{B_{it}}{B_{ct}} \right)^{-(1-\alpha)} \left( \frac{B_{it+1}}{B_{it}} \right)^{-(1-\alpha)} \right]^{1-\alpha} \left( \frac{\rho}{\rho-1} \right)^{1-\alpha} \]  
\[ \frac{B_{xt+1}}{B_{xt}} = \left[ \sum_{i=a,m,s} \theta_i^x \left( \frac{B_{it}}{B_{xt}} \right)^{-(1-\alpha)} \left( \frac{B_{it+1}}{B_{it}} \right)^{-(1-\alpha)} \right]^{1-\alpha} \left( \frac{\rho}{\rho-1} \right)^{1-\alpha} \]

D.1 Aggregate dynamics
To characterize the aggregate dynamics of this economy we need to replace output \( y_t/p_{xt} \), interest rate \( r_t/p_{xt} \), and consumption, investment and sectoral prices \( p_{ct}, p_{xt}, p_{it} \) into
equations (20) and (21), which gives:

\[
\frac{c_{t+1}}{c_t} = \beta \frac{1}{\chi_{t+1}} \left[ \frac{\chi_t}{\chi_{t+1}} \left( \frac{B_{ct+1} B_{zt}}{B_{ct} B_{zt+1}} \right)^{1-\alpha} \right]^{\frac{1}{\delta}} \left[ \alpha \chi_t B_{zt+1}^{1-\alpha} k_{t+1}^{\alpha-1} + (1 - \delta) \right]^{\frac{1}{\delta}} \tag{D.10}
\]

\[
\frac{k_{t+1}}{k_t} = (1 - \delta) + \chi_t B_{zt}^{1-\alpha} k_t^{\alpha-1} - \chi_t \left( \frac{B_{zt}}{B_{ct}} \right)^{1-\alpha} \frac{c_t}{k_t} + \sum_{i=a,m,s} \chi_t \left( \frac{B_{zt}}{B_{ti}} \right)^{1-\alpha} \bar{c}_i \tag{D.11}
\]

Hence, the two difference equations describing the dynamics of the economy only depend on the exogenous investment-specific technical change \(\chi_t\) and in sectoral productivities \(B_{it}\). The aggregate dynamics of the economy do not depend on its the sectoral composition of the economy but on variables that also determine its sectoral composition, the \(B_{it}\). Hence, because the latter are given by sectoral prices, once we control for sectoral prices the movements of the aggregate variables are orthogonal to the sectoral composition of the economy.

**Appendix E: Country by country results**

This Appendix reports two different objects. First, Table E.1 reports the quality of fit of the estimated sectoral shares country by country. In particular, we regress country by country the actual sectoral shares against the model-predicted ones and report the intercept, slope, and \(R^2\). Second, Figure E.1-E.48 reports several time series country by country. Panel (a) plots the value added share of manufacturing in the data (black line) and the one implied by the estimated model (blue line). As it can be observed, the two lines are almost indistinguishable for most countries. Panel (b) compares the estimated model against the counterfactual series for the open economy case. Panels (c) and (d) allows to understand how the model fits the data. Panel (c) reports the time series for the investment rate (red) alongside the time series of the value added share of manufacturing, while Panel (d) plots the model-implied value added share of manufacturing within investment (red line), within consumption (blue line), and within GDP (black line). For almost all countries the estimated value added share of manufacturing within investment is above the one within consumption.
Table E.1: Country fit (first half of countries)

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<tr>
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<th>Agr</th>
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Notes: For each sector (Agr, Man, Ser) and country, the table reports the intercept ($\beta_0$), slope ($\beta_1$) and percentage of variance explained ($R^2$) of a regression of actual sectoral shares against the model-predicted ones.
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Notes: For each sector (Agr, Man, Ser) and country, the table reports the intercept ($\beta_0$), slope ($\beta_1$) and percentage of variance explained ($R^2$) of a regression of actual sectoral shares against the model-predicted ones.
Figure E.3: Austria

(a) Manufacturing share: model fit
(b) Manufacturing share: counterfactual
(c) Investment rate
(d) Manufacturing share by type of good

Figure E.4: Belgium

(a) Manufacturing share: model fit
(b) Manufacturing share: counterfactual
(c) Investment rate
(d) Manufacturing share by type of good
Figure E.5: Brazil

(a) Manufacturing share: model fit

(b) Manufacturing share: counterfactual

(c) Investment rate

(d) Manufacturing share by type of good

Figure E.6: Canada

(a) Manufacturing share: model fit

(b) Manufacturing share: counterfactual

(c) Investment rate

(d) Manufacturing share by type of good
**Figure E.7: Chile**

(a) Manufacturing share: model fit

(b) Manufacturing share: counterfactual

(c) Investment rate

(d) Manufacturing share by type of good

**Figure E.8: China**

(a) Manufacturing share: model fit

(b) Manufacturing share: counterfactual

(c) Investment rate

(d) Manufacturing share by type of good
Figure E.11: Denmark

(a) Manufacturing share: model fit
(b) Manufacturing share: counterfactual
(c) Investment rate
(d) Manufacturing share by type of good

Figure E.12: Dominican Republic

(a) Manufacturing share: model fit
(b) Manufacturing share: counterfactual
(c) Investment rate
(d) Manufacturing share by type of good
Figure E.13: Finland

(a) Manufacturing share: model fit

(b) Manufacturing share: counterfactual

(c) Investment rate

(d) Manufacturing share by type of good

Figure E.14: France

(a) Manufacturing share: model fit

(b) Manufacturing share: counterfactual

(c) Investment rate

(d) Manufacturing share by type of good
**Figure E.15: Germany**

(a) Manufacturing share: model fit
(b) Manufacturing share: counterfactual
(c) Investment rate
(d) Manufacturing share by type of good

**Figure E.16: Honduras**

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(d) Manufacturing share by type of good
Figure E.17: Hong Kong

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(c) Investment rate
(d) Manufacturing share by type of good

Figure E.18: Hungary

(a) Manufacturing share: model fit
(b) Manufacturing share: counterfactual
(c) Investment rate
(d) Manufacturing share by type of good

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**Figure E.19: India**

(a) Manufacturing share: model fit

(b) Manufacturing share: counterfactual

(c) Investment rate

(d) Manufacturing share by type of good

**Figure E.20: Indonesia**

(a) Manufacturing share: model fit

(b) Manufacturing share: counterfactual

(c) Investment rate

(d) Manufacturing share by type of good
**Figure E.21: Italy**

(a) Manufacturing share: model fit

(b) Manufacturing share: counterfactual

(c) Investment rate

(d) Manufacturing share by type of good

**Figure E.22: Japan**

(a) Manufacturing share: model fit

(b) Manufacturing share: counterfactual

(c) Investment rate

(d) Manufacturing share by type of good
Figure E.23: Jordan

Figure E.24: Malaysia
Figure E.25: Mexico

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Figure E.26: Morocco

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Figure E.27: Netherlands

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(d) Manufacturing share by type of good

Figure E.28: New Zealand

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(d) Manufacturing share by type of good
Figure E.33: Philippines

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(d) Manufacturing share by type of good

Figure E.34: Portugal

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(d) Manufacturing share by type of good
Figure E.35: Singapore

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Figure E.36: South Africa

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Figure E.37: South Korea

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Figure E.38: Spain

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Figure E.39: Sri Lanka

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Figure E.40: Sweden

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**Figure E.41:** Switzerland

- (a) Manufacturing share: model fit
- (b) Manufacturing share: counterfactual
- (c) Investment rate
- (d) Manufacturing share by type of good

**Figure E.42:** Taiwan

- (a) Manufacturing share: model fit
- (b) Manufacturing share: counterfactual
- (c) Investment rate
- (d) Manufacturing share by type of good
**Figure E.43: Thailand**

(a) Manufacturing share: model fit

(b) Manufacturing share: counterfactual

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(d) Manufacturing share by type of good

**Figure E.44: Tunisia**

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(c) Investment rate

(d) Manufacturing share by type of good
Figure E.45: Turkey

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Figure E.46: United Kingdom

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(b) Manufacturing share: counterfactual
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(d) Manufacturing share by type of good
**Figure E.47: United States**

(a) Manufacturing share: model fit

(b) Manufacturing share: counterfactual

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(d) Manufacturing share by type of good

**Figure E.48: Vietnam**

(a) Manufacturing share: model fit

(b) Manufacturing share: counterfactual

(c) Investment rate

(d) Manufacturing share by type of good