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The Timing of Industrialization Across Countries

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Abstract

We develop a measure of the timing of industrialization, comparable across 149 countries. Defining the year of industrial transition as the year in which employment in industry exceeded that in agriculture, we identify 67 countries that industrialized between 1801 and 2005 and 82 countries that had not yet industrialized by 2005. We cross validate the data using anecdotal evidence from historians and by showing that, in a subset of countries, industrial production per capita surges around the year of industrialization. We then use the measure to investigate existing theories of industrialization. First, we find that an early transition is associated with higher income today. Second, the industrial transition is closely linked with the fertility transition. Third, early- and late-industrializers have rather similar levels of income, human capital, and structural composition. Fourth, late-comers differ from early-industrializers in terms of being more open to trade, having larger service shares, industrializing faster, experiencing higher growth rates of GDP per capita and schooling, and last by being more heterogenous along several dimensions.

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1 Introduction

The Industrial Revolution transformed Britain from an agrarian society to the World's leading producer of manufacturing goods. It marks a turning point in World history. Before this event, living standards across the globe had been stagnant for thousands of years.¹ The transformation from agriculture to manufacturing spread from Britain to other Western economies and in its wake came sustained economic growth which lifted billions of people out of poverty.

These observations led many economists to argue that growth and industrialization are intrinsically linked. As a consequence, a vast theoretical literature seeks to understand the role that industrialization plays in economic development.² The empirical literature typically investigates the process of industrialization within one country (e.g., Michaels *et al.* (2012)) or across a smaller group of countries (e.g., Bairoch (1982), Duarte & Restuccia (2010)). There are, to our knowledge, no studies investigating the spread of industrialization across the World.

The primary goal of the present paper is to establish a measure of the timing of the transition from agriculture to industry, which is comparable across countries and applicable to a large enough number of countries to draw valid conclusions. We argue that the year where the industrial labor force exceeds the agricultural labor force fits the bill. In what follows, it is referred to as the year of the industrial transition or YIT.

Based on data from different sources, we identify 67 countries that have gone through an industrial transition between 1801 and 2005. We refer to these countries as industrialized. Likewise, we identify 82 countries that were not industrialized by 2005. The first country to industrialize was the United Kingdom in 1801. Around the turn of the 19th century, it was followed by a small group of Western European countries and their colonial offshoots. The next wave of industrializations occurred in the 1930's and 1940's, mostly in Western and Central European economies.

Our measure of industrial transitions coincides with dates argued by historians. We further cross-validate our measure using historical data on industrial production per capita available

¹This period of stagnant living standards has been termed the Malthusian era. It refers to the period, where increases in technology levels merely translated into more surviving people, and not more income per person (see also empirical evidence by ?).

²E.g., Kuznets (1973), Hansen & Prescott (2002), Strulik & Weisdorf (2008), Lucas (2009).

for 16 countries. Reassuringly, we find that the increase in industrial production is particularly rapid in the years just before and just after the year of the industrial transition.

The secondary goal of the paper is to exploit the YIT data to present facts which are useful in evaluating models of structural change. We do not claim to establish causality or provide definitive tests. Instead, we produce a number of correlations and plots which serve as a rough consistency check of several prominent theories of industrialization.

Most of these theories claim that there is a link between industrial transitions and modern economic growth. Our starting point is to investigate whether this conjecture is supported by the data. This leads to our first stylized fact:

1. Countries with early YITs are relatively richer today, whereas the richest non-industrialized today country has an income of around one third of the United States. Earlier transition to industry does not, however, linearly bring higher GDP per capita. For instance, countries that industrialized in the early 1900's enjoy the same incomes today as those that industrialized 50 years later.

We then examine the idea that the timing of the transition from a high-fertility regime to a low-fertility regime is related to the process of industrialization. This leads to the second stylized fact:

2. There is a positive and relatively tight and linear relationship between the timing of the industrial transition and the timing of the fertility transition. However, a group of Western European countries and European offshoots experienced the same low fertility patterns as the early industrializers, but yet did not industrialize until 50-100 years later.

To further investigate the anatomy of the industrial transition, we pick five variables suggested by the literature to be intrinsically linked to industrialization: income, human capital, trade, institutions, and structural composition (measured as employment share in services). We examine these variables around the time of transition. The idea behind this exercise is illustrated by the following example. Suppose a theory posits that a certain level of human capital triggers industrialization. If there is some truth to this hypothesis, we would expect human capital to be relatively constant at the time of the transition across transitions in different countries and time periods. Many theories of industrialization implicitly claim that the

key implicated variables behave uniformly across transitions.³ There are also theories which explicitly assume that the process differs over time. Kuznets (1973) argued that the unindustrialized countries in his time were fundamentally different from what the industrialized countries looked like prior to their industrial transitions.

By examining these variables (income, human capital, trade, institutions, and structural composition) around YIT, we claim to check the validity of the theories in question. Our findings are summarized in the third and fourth stylized facts:

3. Countries going through an industrial transition have a few things in common, independent of whether they industrialized 10 or 200 years ago: Roughly the same levels of income, levels of education, and share of the labor force in services. For instance, the average years of schooling in transitioning countries is usually close to 6. Hence, the data supports theories which predict that the level of human capital, income, and/or structural composition play key (and unchanged) roles in the transformation from agriculture to industry.

4. The latecomer differ from the early industrializers along the following dimensions: They industrialize faster and experience higher growth rates of GDP per capita and education at the time of transition, potentially due to technological catch-up: Late industrializers do not have to develop new technologies but can exploit those already developed by early industrializers. Further, late industrializers are more open to trade and experience higher shares of the labor force employed in services. Last, the level of democracy does not seem to matter for industrialization; most countries lie in the tails of the polity2 index when they industrialize, i.e. being either full autocracies or full democracies.

The structure of the paper is as follows. Section 2 presents our measure of industrial transitions and validates it against historical data. Section 3 investigates the correlation between income today and the year of industrialization. In Section 4, we examine the relationship between the timing of the fertility transition and the timing industrial transition. Section 5 explores how uniform the process of industrial transitions is across time and space. Section 6 concludes.

³See, e.g., Galor (2005), Hansen & Prescott (2002), Lucas (2009), Strulik & Weisdorf (2008).

2 Dating industrial transitions

We measure the timing of the industrialization process as the year in which employment in industry exceeded employment in agriculture. We call it the year of the industrial transition, or YIT. Of course, the industrial transition does not happen from one year to the next. It is a gradual process, and YIT should be seen as a point in time that is useful for cross-country comparisons. One alternative to choosing a specific date to mark the transition would be choosing two dates - a starting point and an end point of the transition process. Both such dates would be as arbitrarily chosen as the year where industry overtakes agriculture as a source of employment. We therefore prefer to associate the transition process with one single date, since it leaves us with just one judgement call to make.

The employment cut-off that defines YIT is not entirely arbitrary. It marks the date where the political power, at least in democratic countries, tips in favor of industry. And, as we show in Section 2.3, it generates transition dates that correspond closely to what historians would find reasonable.

While agriculture is dominant in traditional low-income societies, both industry and the service sector are big employers in countries that have industrialized. One might therefore argue that if the aim is to analyze economic modernization, service sector employment should be treated similar to industrial employment. There are, however, reasons not to do so. The service sector spans everything from peddlers to brain surgeons. In fact, the service sector of Suriname is of the same size as that of Spain, but there is presumably less brain surgeons in the former. Consequently, in our baseline measure of YIT, we choose to disregard the service sector. As a robustness check, we calculate an alternative YIT defined as the year in which employment in industry and service combined exceeded that in agriculture (or in other words the year where agricultural employment falls below a certain fraction of total employment). The correlation with the baseline measure of YIT is 0.94, indicating that our original series of YIT is robust to this change in definition.⁴

⁴This rather high correlation covers that many poor countries drop out of the dataset, since they enter the data sources with industry+service to agriculture ratios above 1. Or in other words, according to this measure, they were already industrialized before they enter the dataset.

2.1 Data and methodology

Our measure of YIT is constructed using employment data from eight different sources: Mitchell (2007), Groningen growth and Development Centre, Integrated Public Use Microdata Series (IPUMS), Easterly & Fischer (1994), The International labor Organization (ILO), World Development Indicators (WDI), and Shaw-Taylor & Wrigley (2012) for the United Kingdom.⁵

We split employment into agriculture, industry, and services based on the International Standard Industry Classification (ISIC), Rev 3.1. Agriculture includes agriculture, hunting, fishing, and forestry (ISIC A-B). Industry includes mining and quarrying, manufacturing, construction, and utilities (electricity, gas, and water) (ISIC C-F). Services include everything else (ISIC G-P).⁶ This classification corresponds to that used in the World Development Indicators data set.

We define the year of industrialization as the *latest* year in which employment in industry exceeds agriculture. This means that the countries that have deindustrialized within the sample period will be coded as not industrialized unless they industrialize again before 2005.⁷ There are two main reasons for choosing the latest year. First, we define industrialization as achieved only if the country is able to sustain it. Second, the earliest data on employment (Mitchell (2007)) is only available for the most prosperous countries and if we took the earliest year in which industry exceeds agriculture, we could commit a bias in favour of prosperous countries industrializing earlier. The YIT measure based on the latest year in which employment in industry exceeds agriculture is highly correlated with a measure that instead takes the earliest year (the correlation is 0.95). In fact, only 7 countries obtain a different YIT, and 9 of our not-industrialized countries are coded as industrialized when using the earliest year (see Appendix A.2).

We calculate the year of industrialization for each of the eight sources. We do not always

⁵For countries that were once united and that industrialized before they split up, we give all the new countries the same industrialization year as when they were unified. Particularly, Slovenia, Croatia, Macedonia, Serbia, and Montenegro all industrialized at the same time as the united Yugoslavia; in 1981. Likewise, Slovakia and the Czech Republic industrialized at the point in time when the united Czechoslovakia industrialized.

⁶Services include wholesale and retail trade, restaurants and hotels, transport, storage, communications, financing, insurance, real estate and business services, community, social, and personal services.

⁷Appendix A.2 deals with the issue of deindustrialization. There are 16 countries that have deindustrialized within the sample period.

have data for each year, but mostly for every tenth year. To calculate the exact year, we interpolate linearly between the year before and the year after employment in industry exceeds agriculture.⁸ If the country is already industrialized according to our definition when it enters the dataset, we set the YIT as missing. In cases where we have more than one data source for one country, they are rarely in perfect agreement about the employment numbers. Different data sources will therefore yield slightly different YITs.⁹ In this case, we simply pick the latest YIT.

We record whether a country had not yet industrialized by 2005. In some countries data for 2005 is missing. To avoid losing observations we use data from the years prior to 2005 to infer whether the country is industrialized in 2005. For instance, if the latest year of employment data for one country is 1995, we code the country as not industrialized in 2005 if the ratio of industrial to agricultural employment in 1995 is lower than the lowest ratio from which any country has ever managed to industrialize within 10 years.

A number of countries (37) enter the dataset after they industrialized. These countries are not part of our YIT dataset. These consist of many small islands, a group of Middle Eastern countries (Saudi Arabia, Qatar, Kuwait, United Arab Emirates), and a group of small and wealthy countries (Luxembourg, Hong Kong, Iceland, Macao, Malta).

The produced data of industrial transitions can be found in Appendix A.1, Table 4.

2.2 Descriptive statistics

67 countries in our sample industrialized between 1801 and 2005, while 82 countries had still not industrialized by 2005. Some examples are listed in Table 1. Not surprisingly, the United Kingdom was the first industrializer, in 1801. It remained as the only industrialized country until the late 19th century, where first Belgium and then a handful of other European countries followed suit. The European off-shoots - New Zealand, Australia, and the United States - industrialized shortly thereafter, in the early 20th century. As shown in Figure 1, this group of early industrializers were separated from the next wave of industrialization by two World

⁸We only interpolate between years within the same source, not between sources.

⁹See Appendix Table 2 for correlations between YIT produced by the different sources.

Wars and the Great Depression. So, while Scandinavia industrialized in the 1930’s, most other Western European countries had their industrial transition postponed until the golden decades after World War II.

The first country without European heritage to industrialize was Japan, in 1962. Russia followed shortly after along with a handful of countries in the European periphery (both East and West). From the 1970’s onwards, industrial transitions became for the first time a global phenomenon. Starting with the OPEC countries and followed by the emerging markets in South East Asia and Latin America, the past four decades have witnessed a surge in the spread of industrialization (see Figure 1).

Table 1: Examples of YITs

| Country | YIT | Country | YIT | Country | YIT |
|----------------|------------|----------------|------------|----------------|------------|
| United Kingdom | 1801 | Sweden | 1933 | Venezuela | 1971 |
| Belgium | 1884 | France | 1950 | Libya | 1973 |
| Germany | 1896 | Italy | 1961 | South Korea | 1984 |
| Netherlands | 1897 | Japan | 1962 | Chile | 1986 |
| United States | 1911 | Soviet Union | 1963 | Malaysia | 1990 |

Notes: Examples of industrial transition years (YIT). See the full list of countries and YITs in Appendix A.1, Table 4. Sources: Mitchell (2007), Groningen growth and Development Centre, Integrated Public Use Microdata Series (IPUMS), Easterly & Fischer (1994), The International labor Organization (ILO), World Development Indicators (WDI), and Shaw-Taylor & Wrigley (2012).

2.3 Validation

To check whether the year of industrial transition (YIT) as defined in this paper is indeed capturing a crucial point in the industrialization process, we compare it to a dataset of historical manufacturing output compiled by Bairoch (1982). The dataset spans a relatively small subset of the countries in our sample (16 to be precise), and data is only available for 1800, 1860, 1913, 1928, and 1956. In Figure 2, these data points are plotted against the distance (in years) to YIT for each country.¹⁰ Although the countries in the subsample have YITs ranging

¹⁰Note that India (IND), China (CHN), and Mexico (MEX) are included in the figure, even though they have not industrialized as of 2005 according to our definition. Here, we have coded them with a YIT of 2005.

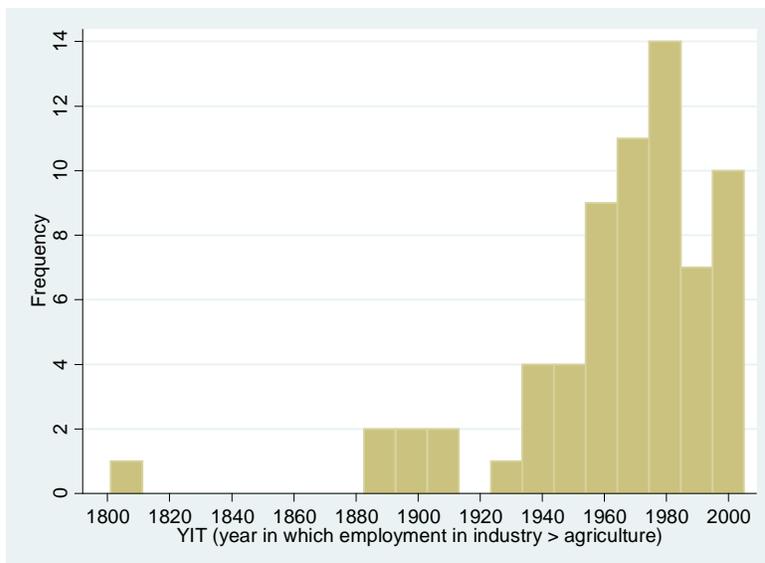


Figure 1: Number of countries in the various industrial transition years (YIT). The Figure includes only the 67 countries that industrialized in the period 1801-2005. *Source:* Own calculations, described in text.

from 1801 (UK) to 2005 (Brazil), the pattern seems quite homogenous. The data points form an S-shape that clearly illustrates the industrial transition. The curve is steep around zero, indicating that YIT is indeed capturing a moment in the transition process where countries are industrializing rapidly.

3 Industrialization and economic development

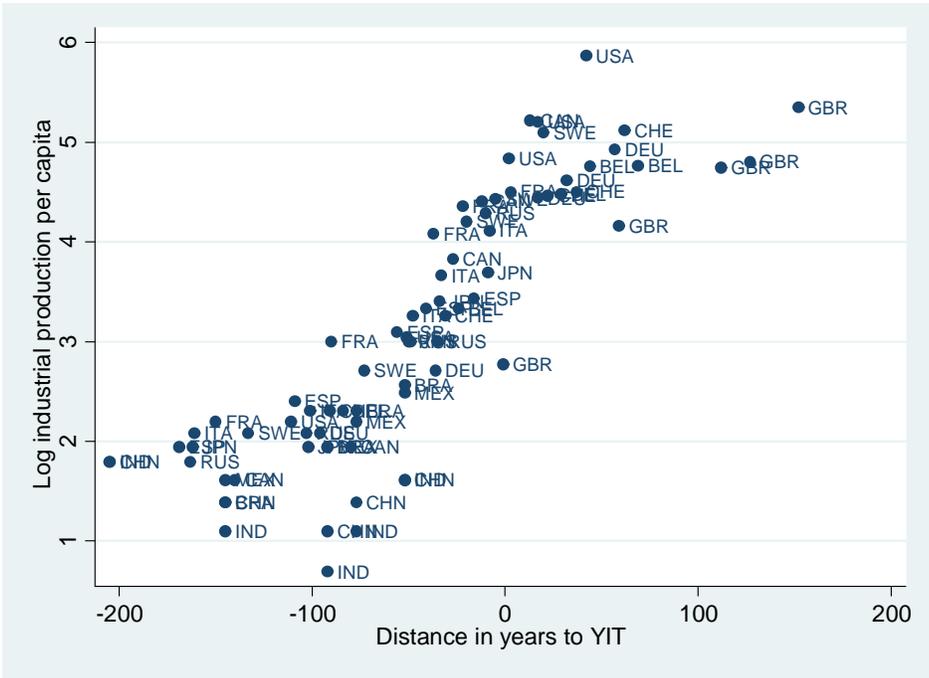
We will now use the YIT dataset to investigate various theoretical predictions from the literature on structural change.¹¹ Our analysis is based on a number of plots and correlations and we are not able to draw any causal inference from the evidence we present.

A popular narrative in the literature is that industrialization puts the economy on a path of sustained economic growth.¹² The implication is that the earlier a country goes through the industrial transition, the higher income it will enjoy today. Figure 3 shows that there is a

Excluding them yields an even better fit with our YIT data.

¹¹See, e.g., Hansen & Prescott (2002), Galor (2005), Strulik & Weisdorf (2008), Lucas (2009).

¹²E.g., Kuznets (1973), Lucas (2009).



significant negative correlation between YIT and GDP per capita in 2005 for the 65 countries that transitioned over the period and for which we have current GDP data. The richest country which is not industrialized, Equatorial Guinea, has an income per capita which is about 1/3 of that of the United States. Moreover, the average income of the industrialized countries is more than five times larger than the non-industrialized countries.¹³ This supports the idea that industrialization is linked with economic development.

The relationship between income today and year of industrialization is not entirely linear. The countries that industrialized in the mid-1900's have approximately the same present-day income levels as the group of first-industrializers. The mid-century industrializers are mostly Western European countries and the picture is therefore consistent with theories of regional catch-up and club convergence. The few mid-century industrializers that lie below the regression line in Figure 3 include Russia as well as the communist Soviet dominions in Eastern Europe. A possible explanation for this is that the outcome of industrial transitions depends on institutions.

4 Industrialization and the fertility transition

Historians have long noted a relation between the industrial and the demographic transition. The demographic transition refers to the transition from high birth and death rates to low rates of both and has long been associated with the industrial transition. More recently, the so-called unified growth models of Galor (2005) and Galor & Weil (2000) have formalized the idea that the fertility transition marks the point where the economy transitions from a stagnant Malthusian state to a sustained growth path. In the Malthusian state of the World, productivity improvements simply translated into larger populations, leaving productivity per capita unchanged. Although traditional unified growth models do not model structural change explicitly, Galor (2005) points out that the demographic transition is often accompanied by an industrial transition.¹⁴ Moreover, Strulik & Weisdorf (2008) and Vollrath (2009) extend

¹³In 2005, the average income per capita of the 81 non-industrialized countries was 3,451\$, compared to 18,604\$ for the 65 industrialized countries.

¹⁴Dalgaard & Strulik (2013) show empirically that there is a strong association between the timing of the fertility transition and income today.

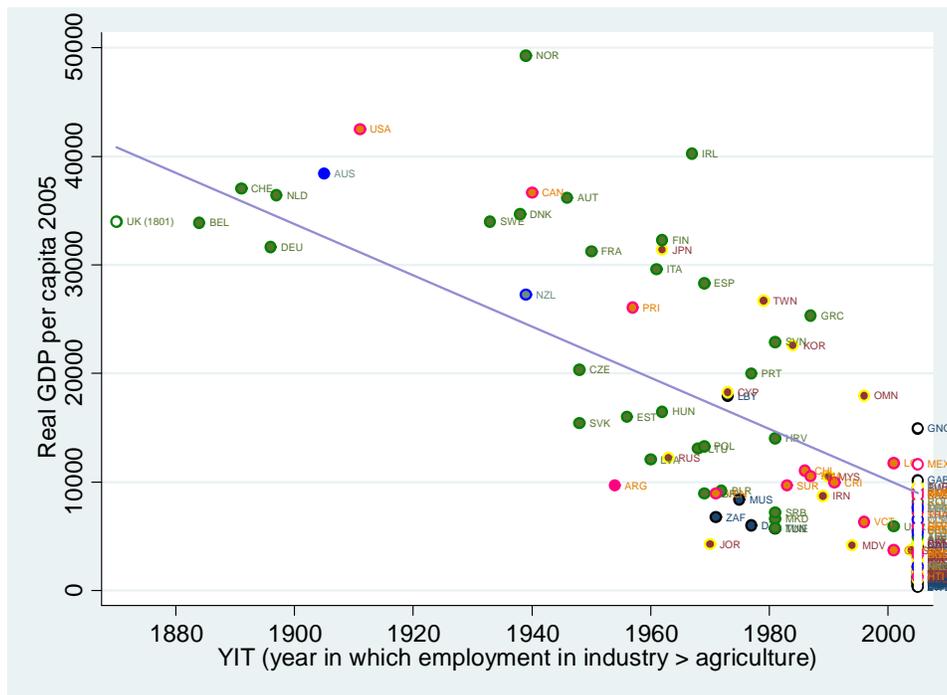


Figure 3: Correlation between real GDP per capita in 2005 and YIT for 146 countries. The fitted line is the raw correlation for the countries that were industrialized by 2005. The correlation coefficient for these 65 countries is -0.69^{***} . Hollow dot means not yet industrialized, except for UK where it means a data-break as UK industrialized in 1801. Colour coding according to continents: Oceania (blue), Africa (black), Europe (green), Americas (red), and Asia (yellow). *Sources:* Real GDP: Penn World Tables, YIT: own calculations.

the framework by incorporating structural transformation. According to these theories, the process of industrialization and the fertility transition should occur at roughly the same time.

Figure 4 plots the year of the demographic transition vs. YIT.¹⁵ The grey line is a 45-degree line and the blue line is a regression line. The slope of the regression line is positive and the R^2 is 0.44, which supports the idea that the two transitions are connected. All of the early industrializers lie above the 45-degree line, indicating that industrialization arrives before the fertility transition. Interestingly, almost all of the countries industrializing after 1920 lie below the line, indicating that the order of transitions is reversed. A group of Western European countries and two of their offshoots (Canada and Argentina) are clustered particularly far below the 45-degree line. In these countries, the fertility decline occurs in the early 1900's around the same time as the group of the earliest industrializers, but they do not industrialize until some 50-100 years later. It seems that the culture of low fertility spread relatively fast to the neighbours of the early-movers, whereas the industrial transition did not arrive until much later. This suggests that the link between the two types of transitions is not as intimate as the theories of fertility and structural change would predict.

5 The process of industrialization in a comparative perspective

Most theoretical models of industrialization and economic transitions stipulate that the industrialization process is essentially uniform across space and time. In this section, we investigate whether we can track this uniformity in the data. We pick the following five variables which are commonly linked to industrialization in the literature: Income, human capital, trade, institutions, and the share of the labor force in the service sector.

¹⁵The data for the year of the demographic transition is taken from Reher (2004). It is defined as the first year where the crude birth rate has declined by at least 8% over 10 years and never increases again to the same level.

5.1 Income

According to some theories, industrialization occurs when the level of income passes some threshold. For instance, in the model by Murphy *et al.* (1989), the presence of large fixed costs generates the potential for a pre-industrial trap with no or low growth. A big demand push is required to initiate a process of structural change. This theory predicts that industrialization should occur at roughly the same level of income per capita where domestic demand is large enough to instigate an escape from the trap.

Figure 5 plots income per capita from Maddison at the year of industrialization vs YIT.¹⁶ Again, countries that had not yet industrialized in 2005 are plotted as if they had a YIT of 2005, indicated by a hollow dot. The regression line drawn in Figure 5 indicates the correlation between income per capita in YIT and YIT for the 45 industrialized countries for which we have historical GDP data. Countries which are not industrialized in 2005 are included in the figure for sake of comparison, but the fitted line is based on the sample of industrialized countries.

Income per capita at YIT is around 4000\$ on average, and varies from 2000\$ to 6500\$ up until 1960. This seems to be a relatively narrow band, especially when one takes into account measurement error in both data series. The uniformity of income at the time of industrialization supports the idea that industrialization occurs at a certain income threshold and thus that income plays some role in the industrialization process.

The period after 1960 reveals a somewhat different picture. The average income level of industrializers in this era increases to 5500\$, ranging from 2400\$ in Jordan to 10500\$ in Venezuela. The variability increases by half a standard deviation. Most of the industrialized countries obtain income levels well beyond 5000\$, yet industrialize rather late. Further, 10% of the countries that were not industrialized by 2005 enjoyed average per capita incomes above 5000\$. Thus, the role of income in the process of industrialization is somewhat more heterogenous in this period.

Figure 6 plots the average growth rate in income from 10 years before the time of industrialization (YIT) to 10 years after YIT vs. YIT. On average, later industrializers go through the

¹⁶Real GDP per capita from Maddison is available online at www.gdpc.net/maddison/.

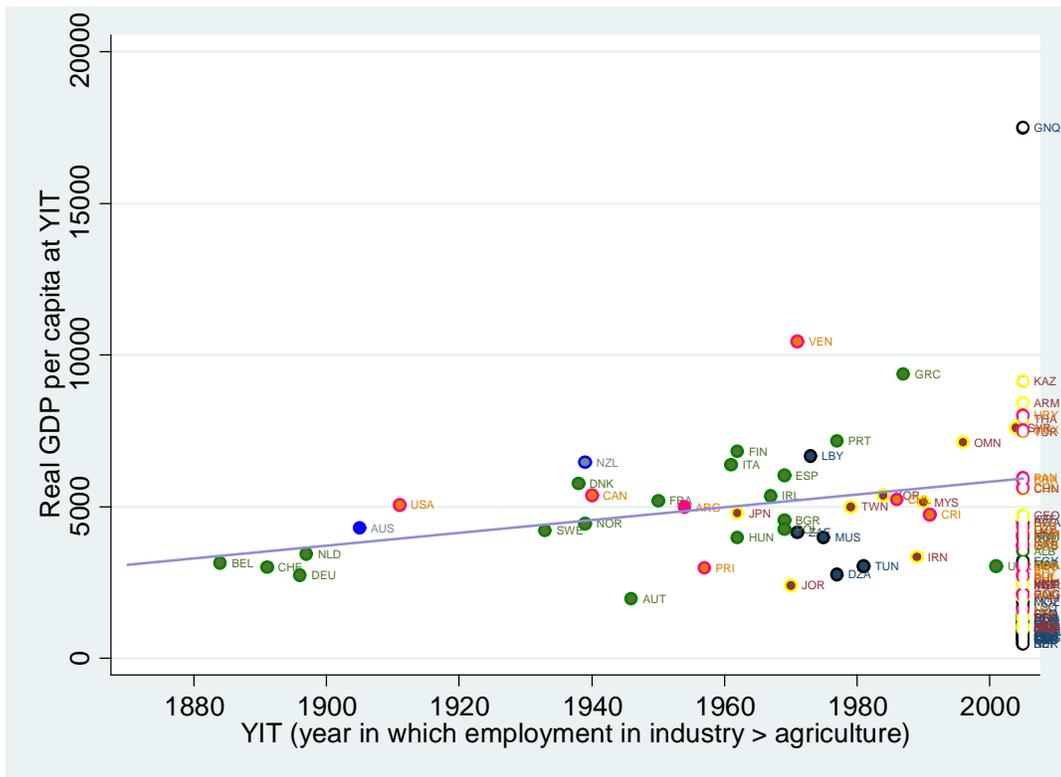


Figure 5: Simple plot of real GDP per capita in YIT against YIT for 116 countries. The fitted line is the raw correlation for the countries that were industrialized by 2005. The correlation coefficient for these 45 countries is 0.38 (p-value = 0.00). Hollow dot means not yet industrialized. Colour coding according to continents: Oceania (blue), Africa (black), Europe (green), Americas (red), and Asia (yellow). *Sources:* Real GDP: Maddison, YIT: own calculations.

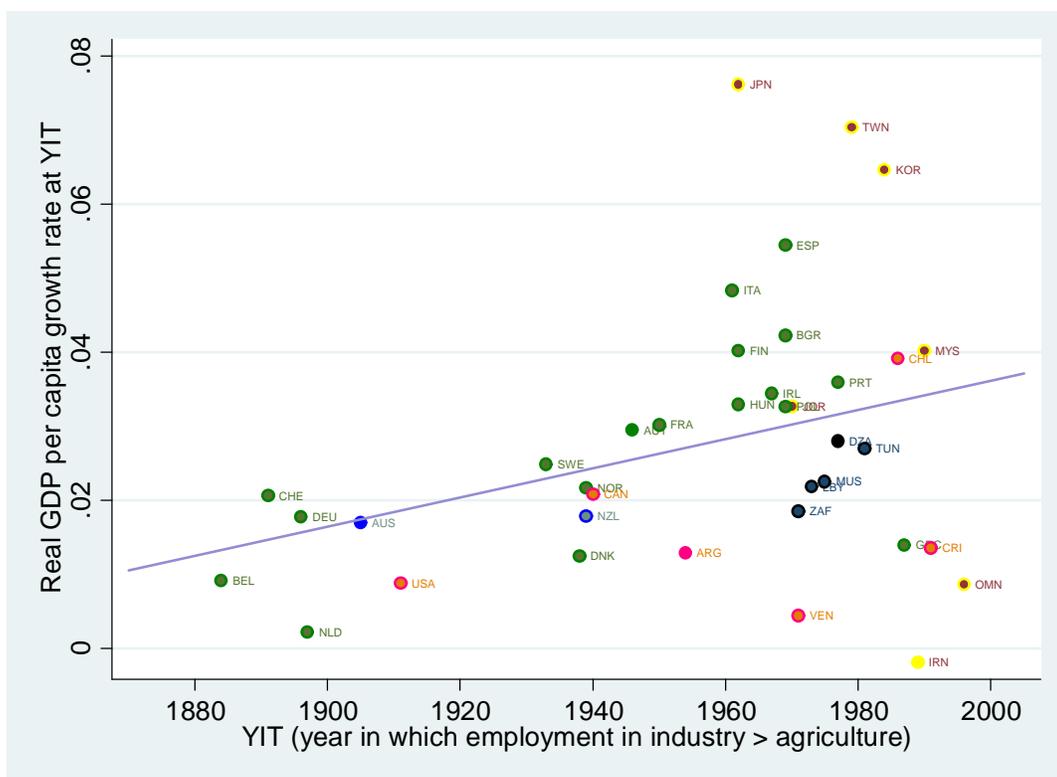


Figure 6: Simple plot of average yearly growth rate of real GDP per capita from 10 years before the year of industrialization (YIT) to 10 years after against YIT for 38 industrialized countries. The fitted line is the raw correlation for the countries that were industrialized by 2005. The correlation coefficient for these 38 countries is 0.33 (p-value = 0.04). Colour coding according to continents: Oceania (blue), Africa (black), Europe (green), Americas (red), and Asia (yellow). *Sources:* Real GDP: Maddison, YIT: own calculations.

industrialization process with higher GDP growth rates. For countries industrializing before the 1960's, the average growth rate is 1.8%, ranging from the Netherlands who managed to industrialize with a GDP growth rate as low as 0.2% to France who industrialized with a growth rate of 3%. After 1960, the average growth rate nearly doubles to 3.3% and the variation nearly tripples. The fast growers are mainly European and Asian countries. Africa grows somewhat slower at the time of industrialization, but still faster than the earliest industrializers. This picture is consistent with a story of technological catch-up which would predict that latecomer , once they get on the path of industrialization, grow faster than the early industrializers.

5.2 Human capital

Caselli & Coleman (2001) and Lucas (2004) argue that human capital accumulation facilitates structural change. A central assumption is that the industrial sector is relatively more skill intensive implying that the return to education is higher and that educated labor tends to be placed in the industrial sector. The level of human capital is thus intrinsically linked to the allocation of labor between the industrial and the agricultural sector.

If this idea has some general applicability, we would expect that the level of education is roughly similar across countries around the time of industrialization. To check whether this is the case, Figure 7 plots education measured by years of schooling at the time of industrialization vs. YIT. As in the previous figures, countries which are not industrialized in year 2005 are plotted as if they had a YIT of 2005, indicated by a hollow dot. The fitted line is only calculated for the industrialized countries.

The average level of schooling at the time of industrialization seems to lie within a relatively narrow band. On average, countries industrialize at a level of schooling of around 6 years. However, as with GDP per capita, there is more heterogeneity across transitions occurring after 1960.¹⁷ African and Middle Eastern countries industrialize with somewhat lower levels of schooling than the rest. The average years of schooling in the African and Middle Eastern countries is 3.8 at the time of industrialization, nearly half the level of the remaining countries industrializing after 1960.

A high level of education does not seem to be a sufficient requirement for industrialization, though. In fact, the country with the highest level of education in the sample (Sri Lanka) belongs to the set of non-industrialized countries. However, as expected, the countries with the lowest levels of education also belong to the group of non-industrialized countries.

The figure also plots the average education level for the group of countries which are not industrialized in a given year.¹⁸ Interestingly, this level increases over time, especially in the

¹⁷The variance in years of schooling at YIT is 90% larger across the sample of 35 countries industrializing after 1960 than for the sample of 16 countries industrializing before 1960.

¹⁸The data on education levels is available from Morrisson & Murin (2009) from 1870 onwards. We calculate the average level of education across all non-industrialized countries from 1870 until they industrialized. Unfortunately, we are not able to make this exercise for the other correlates of industrialization, as these data are not available for enough countries sufficiently far back in time.

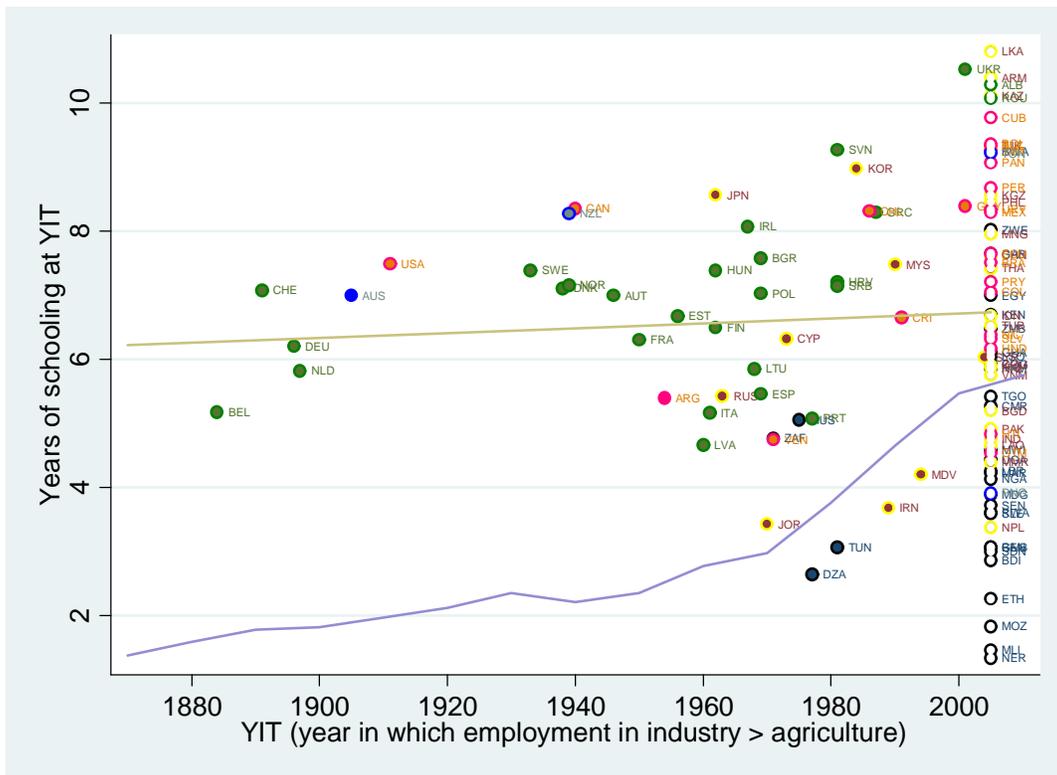


Figure 7: Simple plot of average years of schooling in YIT against YIT for 117 countries. The fitted grey line is the raw correlation for the countries that were industrialized by 2005. The correlation coefficient for these 51 countries is 0.07 (p-value = 0.62). The blue connected line is the education level of the countries that had not industrialized in a given year. Hollow dot means not yet industrialized by year 2005. Colour coding according to continents: Oceania (blue), Africa (black), Europe (green), Americas (red), and Asia (yellow). *Sources:* Years of schooling: Barro & Lee (2012) and Morrisson & Murtin (2009), YIT year: own calculations.

period after 1970. Moreover, there is large group of countries with education levels above 8 today, but which have not industrialized. This might be evidence against the hypothesis that there is a threshold above which countries industrialize. Another interpretation is that a low quality of schooling has mitigated the impact of increases in the quantity of schooling.¹⁹

Figure 8 plots the change in schooling from 10 years before to 10 years after YIT against YIT. The figure reveals a similar picture as that of GDP growth rates: Countries that industrialize later experience much higher growth rates at the time of industrialization. Four of the five Middle Eastern and African industrialized countries with lowest levels of human capital from Figure 7 experience above-average growth rates, potentially as a sign of catch-up in education levels. However, most of the fast growers are the countries with the same average levels of schooling as the early industrializers.

5.3 International trade

Williamson (2011) points to yet another correlate of industrialization. He suggests that the latecomers may have been crowded out by the early industrializers via international trade. In particular, he shows that prices on manufactures in industrialising countries decreased while demand for primary commodities from the 'poor periphery' increased as a result of early industrialization. This incentivized the poor periphery to stick with agricultural production, hindering their industrialization process. An implication of this hypothesis is that industrialization among the latecomers could be facilitated by protecting infant industries by way of trade policy closure. That is, we would expect that the latecomers industrialize at lower levels of openness than the early industrializers. We check this by plotting openness at the time of industrialization against YIT in Figure 9.^{20,21}

¹⁹This explanation has been suggested by e.g. Pritchett (2001).

²⁰We measure openness by the share (Imports+Exports)/GDP. Penn World Tables provides data for most countries from 1960. Before that, we use Mitchell (2007).

²¹Another testable implication of the Williamson hypothesis is that industrialization cannot occur at 'too high' levels of agricultural exports. The Penn World Tables provides data on trade by sectors from year 1950. Unfortunately, we do not have earlier comparable data. For most industrialized countries, the share of food and beverages exports at the time of industrialization lies rather constant below 10%. However, if anything, the average for the 33 countries industrializing between 1950 and 2005 is higher than the average for the 73 countries that had not industrialized by 2005. This would speak against Williamson's hypothesis.

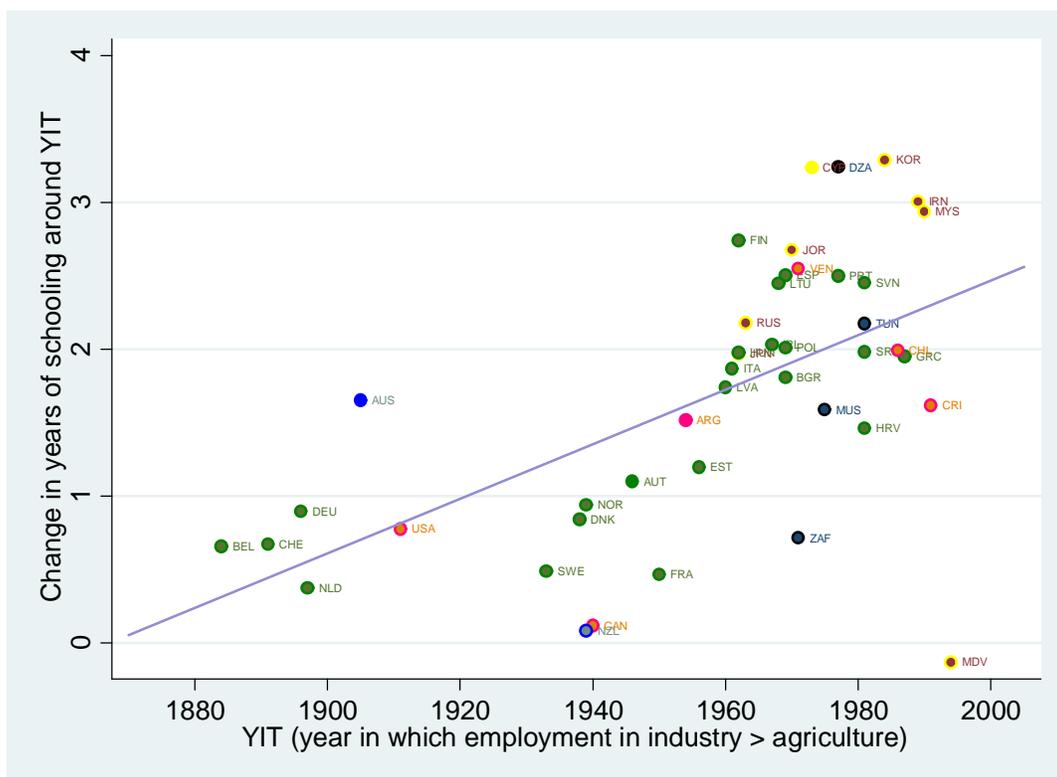


Figure 8: Simple plot of the change in years of schooling from 10 years before to 10 years after YIT against YIT for the 44 countries that were industrialized by 2005. The fitted line is the raw correlation, which is 0.58 (p-value = 0.00). Hollow dot means not yet industrialized by year 2005. Colour coding according to continents: Oceania (blue), Africa (black), Europe (green), Americas (red), and Asia (yellow). *Sources:* Years of schooling: Barro and Lee (2011) and Morrisson & Murin (2009) YIT year: own calculations.

Figure 9 shows that the variation in openness around YIT is substantial, especially in the period after 1980. For some countries, trade as a fraction of GDP at YIT is around 10%, for others it is well above 100%. If anything, the latecomer industrialize at *higher* levels of openness than the early industrializers. Only three countries industrialize at lower levels of openness than the early industrializers (Austria, Argentina, and Russia). Further, only one non-industrialized country is less open to trade (Myanmar) than the early industrializers. This does not seem to support the idea that industrialization among the latecomer is facilitated by trade closure.²² It could also cover the idea that the snapshot picture in Figure 9 might have been taken "too late". In other words, the seemingly rise in openness for latecomers could cover a low level of openness prior to industrialization, leading to industrialization as Williamson envisioned, which in turn increased openness. Under the latter interpretation, we would expect to see large increases in the change in openness around the year of industrialization among the latecomers. Figure 13 in Appendix A.3 shows that this is the case for some countries.

5.4 Institutions

Another potential determinant of economic development and industrialization is institutions.²³ Here, we shed light on one aspect of institutions, namely the degree of democracy quantified by the Marshall *et al.* (2010) Polity IV project. We choose this measure since it is widely used in the literature and available for many countries over a long time horizon.

Figure 10 plots the polity2-index in the YIT against YIT.²⁴ The polity2 index ranges from -10 to 10 and measures the degree of democracy in a country, higher numbers indicating more democracy. Figure 10 shows that industrialization happens at various levels of democracy, though mainly either full democracy (near +10) or full autocracy (near -10). Part of this is a mechanic result of the fact that most countries lie in the tails of the polity2 range. Only 27% of the total sample lie within the midrange of -6 to +6 in year 2010. However, the 'midrange-share' is larger for the countries that had not yet industrialized in year 2005 (41%) compared to

²²The increase in openness for late industrializers is consistent with the general trade boom over the period.

²³E.g., Acemoglu *et al.* (2001), Acemoglu *et al.* (2002), Dell (2010), North (1990), Engerman & Sokoloff (2000).

²⁴The polity2-index data is available online from www.systemicpeace.org/polity/polity4.htm.

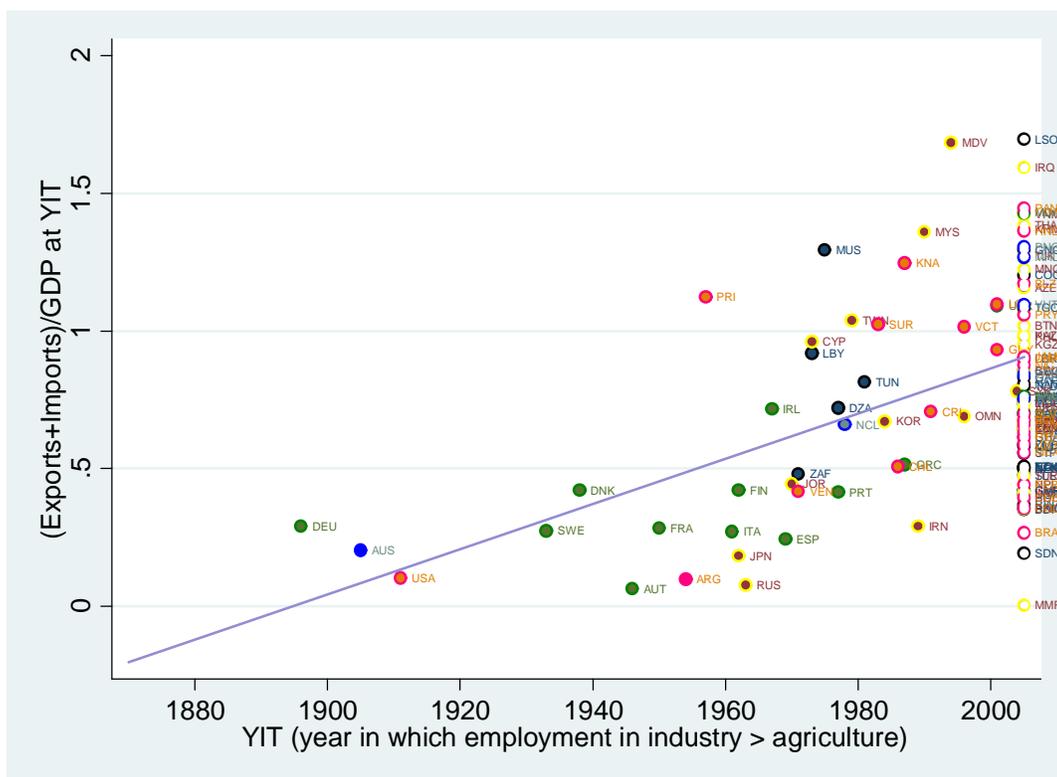


Figure 9: Simple plot of openness in YIT against YIT for 127 countries. The fitted grey line is the raw correlation for the countries that were industrialized by 2005. The correlation coefficient for these 45 countries is 0.52 (p-value = 0.00). Hollow dot means not yet industrialized by year 2005. Colour coding according to continents: Oceania (blue), Africa (black), Europe (green), Americas (red), and Asia (yellow). *Sources:* (Exports+Imports)/GDP: Penn World Tables and Mitchell (2007), YIT year: own calculations.

change is towards democracy (results available upon request).²⁵

5.5 Structural composition

It has been widely acknowledged that the structural transformation that occurs with industrialization is a process where labor is first allocated from agriculture to industry and then later from industry to services (see e.g., the model by Duarte & Restuccia (2010)). However, ? show that within the last 25 years the pattern of structural change has been different for some developing countries. In particular, in a number of low-income countries in Africa and Latin America, labor has floated from the agricultural sector into a low-productive service sector.

To investigate how homogenous the sequence of structural change is, Figure 11 plots the share of the labor force employed in the service sector at the time of industrialization against YIT. Except from a few Asian and Latin American countries, the service share in the YIT is relatively constant, which indicates some degree of uniformity in the process. Most countries industrialize with service shares around 40%.

The exceptions to this tendency of homogeneity are the four countries to industrialize first in this sample (UK, Belgium, Germany, and Switzerland) industrializing with service shares around 20% and at the other extreme lies a small group of latecomer industrializing with service shares well above 50%. Combined with the fact that the average service share of the non-industrialized countries equals the service shares at the time of industrialization, this suggests that, at least in a recent period, the path of structural change is not necessarily one where substantial increases in the share of the labor force in services only occur after industrialization.

The mirror image of Figure 11 shows the industry and agriculture labor force shares, which by definition are equal at the time of industrialization. While UK industrialized with more than 40% of the labor force employed in industry, Oman industrialized with less than 10% of the labor force being industrial workers.

²⁵We calculate the change in the polity2 measure from 10 years before YIT to 10 years after for 38 countries. Half of these saw no change. Of those that did change, only 3 change to be less democratic.

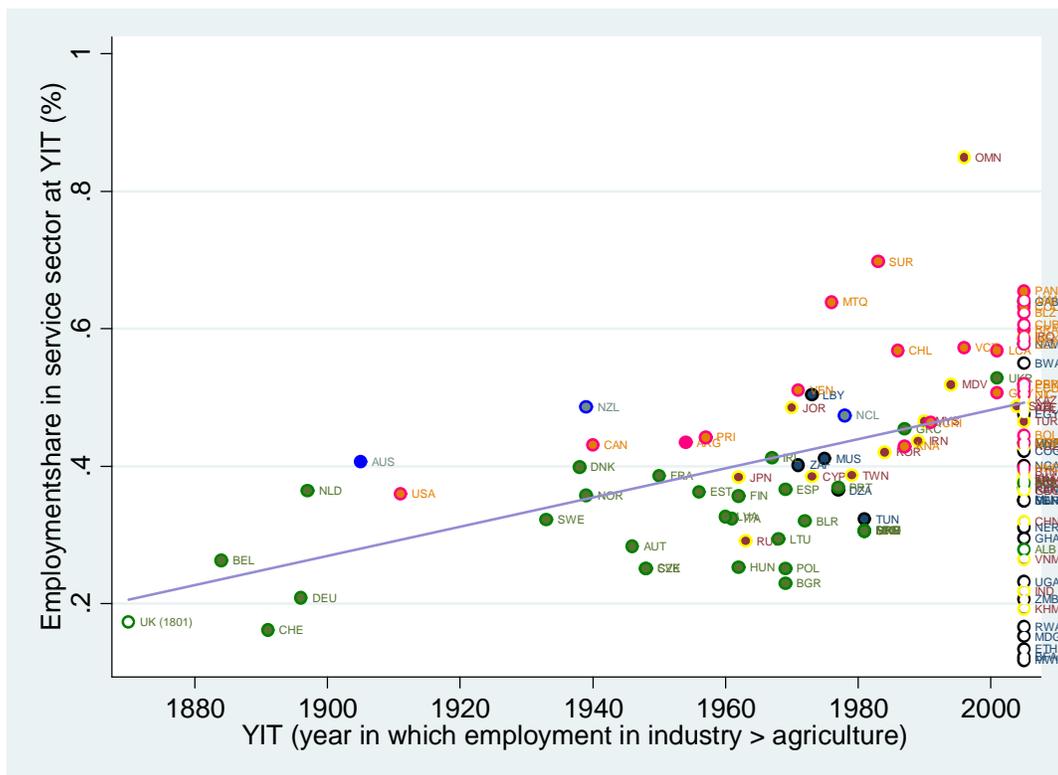


Figure 11: Simple plot of employment share in the service sector in YIT against YIT for 119 countries. The fitted line is the raw correlation for the countries that were industrialized by 2005. The correlation coefficient for these 67 countries is 0.57 (p-value = 0.00). Hollow dot means either not yet industrialized or for UK hollow indicates a data break, since UK industrialized in 1801. Colour coding according to continents: Oceania (blue), Africa (black), Europe (green), Americas (red), and Asia (yellow). *Sources:* own calculations.

5.6 Speed of industrialization

To investigate how fast the typical industrial transition occurs, Figure 12 shows the increase in the ratio of industry to agriculture over the 20-year period around the YIT. An increase of one unit means an increase of 100 percentage points in the industry-to-agriculture ratio. Consider Germany, whose ratio changed by 100 percentage points around its industrialization year (year 1896). This covers a change from 82% being employed in industry relative to agriculture in year 1886 to 182% employed in industry relative to agriculture in year 1906.

Figure 12 also reveals that the transition speed varies from country to country. For many economies, the increase is around 0.5, for others it is around 1.5 or higher. Furthermore, the slope of the regression line is positive and significant, indicating that late industrializers, in general, transition faster. For instance, the earliest industrializer, United Kingdom, is also the slowest. One interpretation of this finding is that early industrializers had to go through the time-consuming process of developing new technologies from scratch, whereas later industrializers could exploit those already developed, i.e., evidence of technological catch-up.

149 countries across the globe. We define the year of industrialization by the year in which employment in industry exceeds that in agriculture. This point in time marks the date where the political power, at least in democratic countries, tips in favor of industry. The numbers that we produce coincide with dates argued by historians and match the point in time where industrial output per capita surged.

With these data at hand, we are able to shed light on some stylized facts with relevance to the debate on why some countries industrialize before others and what this means for income today. We confirm that countries that went through a process of industrialization earlier are richer today. In fact, the timing of industrialization explains 42% of the variation in GDP per capita today. Likewise, the industrial transition goes hand in hand with the demographic transition for most countries. We find signs of technological catch-up; the later industrializers industrialize at a faster rate and with higher levels of growth in GDP per capita and schooling than the countries that industrialized a century ago.

In support of various theories of industrialization, we find certain similarities among the countries going through the industrialization process: Whether these countries industrialized 10 or 200 years ago, they seem to have roughly similar education levels, GDP per capita, and share of the labor force in services. The latter seems to be changing, though, with latecomers industrializing at much higher service shares than the early industrializers. Likewise for trade: Latecomers are markedly more open when going through the industrialization process compared to the 19th century frontrunners. Further, there does not seem to be a link between industrialization and a certain level of democracy. Last, the diversity of industrializers along several dimensions is increasing over time.

Although the stylized facts are roughly consistent with several prominent theories, the data poses as many questions as it answers. With comparable cross-country data on the timing of the industrial transition we hope to leave future scholars better equipped for testing existing theories and developing new theories of the causes and consequences of structural change.

A Appendix

A.1 YIT data

Table 2: Correlation matrix of YIT from the different sources

| | | | | | |
|-------|--------------|--------------|-------------|--------------|--------------|
| | ih | gron | ipums | ilo | wdi |
| ih | 1.00 (52) | | | | |
| gron | 0.79 (9) | 1.00 (13) | | | |
| ipums | 0.96 (4) | 0.94 (3) | 1.00 (6) | | |
| ilo | 0.58 (9) | 0.81 (5) | 0.30 (4) | 1.00 (19) | |
| wdi | 0.27 (9) | 0.80 (7) | 0.36 (6) | 0.99 (15) | 1.00 (25) |

Notes: Correlation coefficients of YIT calculated from the various sources, number of observations in parenthesis. Sources: ih: International Historical Statistics, Mitchell (2007); gron: Groningen Growth and Development Centre Total Economy Database, www.rug.nl/research/ggdc/; ipums: Integrated Public Use Microdata Series, www.ipums.org; ilo: International labor Organization, www.ilo.org; wdi: World Development Indicators, data.worldbank.org. Neither of the two sources Easterly & Fischer (1994) nor Shaw-Taylor & Wrigley (2012) overlap with any of the other sources and are thus omitted from this table.

Table 3: Summary statistics for YIT years from the different sources

| | Obs | Mean | Min | Max |
|----------|-----|------|------|------|
| ih | 52 | 1958 | 1884 | 1991 |
| gron | 13 | 1978 | 1954 | 2005 |
| ipums | 6 | 1981 | 1960 | 1998 |
| ilo | 19 | 1993 | 1973 | 2005 |
| wdi | 25 | 1997 | 1981 | 2005 |
| eastfish | 9 | 1967 | 1956 | 1984 |
| uk | 1 | 1801 | 1801 | 1801 |

Notes: Summary statistics of YIT years for the full set of 149 countries, by sources. Sources: ih: International Historical Statistics, Mitchell (2007); gron: Groningen Growth and Development Centre Total Economy Database, www.rug.nl/research/ggdc/; ipums: Integrated Public Use Microdata Series, www.ipums.org; ilo: International labor Organization, www.ilo.org; wdi: World Development Indicators, data.worldbank.org, eastfish: Easterly & Fischer (1994), uk: Shaw-Taylor & Wrigley (2012).

Table 4. Industrial transition years by country

| Country | YIT | notindu2005 | Source | Country | YIT | notindu2005 | Source |
|-------------------|------|-------------|----------|--------------------------------|------|-------------|--------|
| Albania | 2005 | 1 | ilo | Maldives | 1994 | 0 | wdi |
| Algeria | 1977 | 0 | ihs | Mali | 2005 | 1 | ipums |
| Argentina | 1954 | 0 | gron | Marshall Islands | 2005 | 1 | wdi |
| Armenia | 2005 | 1 | ilo | Martinique | 1976 | 0 | ihs |
| Australia | 1905 | 0 | ihs | Mauritius | 1975 | 0 | ihs |
| Austria | 1946 | 0 | ihs | Mexico | 2005 | 1 | ipums |
| Azerbaijan | 2005 | 1 | ilo | Moldova | 2005 | 1 | ilo |
| Bangladesh | 2005 | 1 | ilo | Mongolia | 2005 | 1 | ipums |
| Belarus | 1972 | 0 | eastfish | Montenegro | 1981 | 0 | ihs |
| Belgium | 1884 | 0 | ihs | Morocco | 2005 | 1 | ipums |
| Belize | 2005 | 1 | ilo | Mozambique | 2005 | 1 | wdi |
| Benin | 2005 | 1 | wdi | Myanmar | 2005 | 1 | ilo |
| Bhutan | 2005 | 1 | wdi | Namibia | 2005 | 1 | ilo |
| Bolivia | 2005 | 1 | ipums | Nepal | 2005 | 1 | ipums |
| Botswana | 2005 | 1 | ilo | Netherlands | 1897 | 0 | ihs |
| Brazil | 2005 | 0 | gron | New Caledonia | 1978 | 0 | ilo |
| Bulgaria | 1969 | 0 | ihs | New Zealand | 1939 | 0 | ihs |
| Burkina Faso | 2005 | 1 | wdi | Nicaragua | 2005 | 1 | ipums |
| Burundi | 2005 | 1 | wdi | Niger | 2005 | 1 | wdi |
| Cambodia | 2005 | 1 | ipums | Nigeria | 2005 | 1 | ilo |
| Cameroon | 2005 | 1 | ilo | Norway | 1939 | 0 | ihs |
| Canada | 1940 | 0 | ihs | Oman | 1996 | 0 | ilo |
| Chad | 2005 | 1 | wdi | Pakistan | 2005 | 1 | ipums |
| Chile | 1986 | 0 | wdi | Panama | 2005 | 0 | wdi |
| China | 2005 | 1 | ipums | Papua New Guinea | 2005 | 1 | ilo |
| Colombia | 2005 | 0 | wdi | Paraguay | 2005 | 1 | ilo |
| Congo, Rep | 2005 | 1 | wdi | Peru | 2005 | 1 | ipums |
| Costa Rica | 1991 | 0 | gron | Philippines | 2005 | 1 | ipums |
| Croatia | 1981 | 0 | ihs | Poland | 1969 | 0 | ihs |
| Cuba | 2005 | 1 | ipums | Portugal | 1977 | 0 | ilo |
| Cyprus | 1973 | 0 | ihs | Puerto Rico | 1957 | 0 | ihs |
| Czech Republic | 1948 | 0 | ihs | Romania | 2005 | 1 | wdi |
| Denmark | 1938 | 0 | ihs | Russian Federation | 1963 | 0 | ihs |
| Dominica | 2005 | 1 | ilo | Rwanda | 2005 | 1 | ipums |
| Ecuador | 2005 | 1 | wdi | Saint Kitts and Nevis | 1987 | 0 | wdi |
| Egypt | 2005 | 1 | ipums | Saint Lucia | 2001 | 0 | wdi |
| El Salvador | 2005 | 1 | wdi | Saint Vincent & the Grenadines | 1996 | 0 | wdi |
| Equatorial Guinea | 2005 | 1 | ilo | Samoa | 2005 | 1 | wdi |
| Estonia | 1956 | 0 | eastfish | Sao Tome and Principe | 2005 | 1 | wdi |
| Ethiopia | 2005 | 1 | ilo | Senegal | 2005 | 1 | ipums |
| Finland | 1962 | 0 | ihs | Serbia | 1981 | 0 | ihs |
| France | 1950 | 0 | ihs | Sierra Leone | 2005 | 1 | ipums |
| Gabon | 2005 | 1 | ilo | Slovakia | 1948 | 0 | ihs |
| Gambia | 2005 | 1 | wdi | Slovenia | 1981 | 0 | ihs |
| Georgia | 2005 | 1 | ilo | South Africa | 1971 | 0 | ihs |
| Germany | 1896 | 0 | ihs | South Korea | 1984 | 0 | gron |
| Ghana | 2005 | 1 | ipums | Spain | 1969 | 0 | gron |
| Greece | 1987 | 0 | ilo | Sri Lanka | 2005 | 1 | ilo |
| Guatemala | 2005 | 1 | ilo | Sudan | 2005 | 1 | ipums |
| Guinea | 2005 | 1 | ipums | Suriname | 1983 | 0 | wdi |
| Guyana | 2001 | 0 | ilo | Sweden | 1933 | 0 | ihs |
| Haiti | 2005 | 1 | ilo | Switzerland | 1891 | 0 | ihs |
| Honduras | 2005 | 1 | ilo | Syria | 2004 | 0 | wdi |
| Hungary | 1962 | 0 | ihs | Taiwan | 1979 | 0 | ihs |
| India | 2005 | 1 | ipums | Tajikistan | 2005 | 1 | wdi |
| Indonesia | 2005 | 1 | ipums | Tanzania | 2005 | 1 | ipums |
| Iran | 1989 | 0 | ihs | Thailand | 2005 | 1 | ipums |
| Iraq | 2005 | 1 | ilo | Macedonia | 1981 | 0 | ihs |
| Ireland | 1967 | 0 | ihs | Togo | 2005 | 1 | wdi |
| Italy | 1961 | 0 | gron | Tonga | 2005 | 1 | ilo |
| Jamaica | 2005 | 1 | ilo | Tunisia | 1981 | 0 | wdi |
| Japan | 1962 | 0 | ihs | Turkey | 2005 | 0 | ilo |
| Jordan | 1970 | 0 | ihs | Uganda | 2005 | 1 | ipums |
| Kazakhstan | 2005 | 1 | ilo | Ukraine | 2001 | 0 | wdi |
| Kenya | 2005 | 1 | wdi | United Kingdom | 1801 | 0 | uk |
| Kyrgyzstan | 2005 | 1 | ipums | United States | 1911 | 0 | ihs |
| Laos | 2005 | 1 | wdi | Uruguay | 2005 | 1 | ipums |
| Latvia | 1960 | 0 | eastfish | Uzbekistan | 2005 | 1 | wdi |
| Lesotho | 2005 | 1 | ilo | Vanuatu | 2005 | 1 | wdi |
| Liberia | 2005 | 1 | wdi | Venezuela | 1971 | 0 | ihs |
| Libya | 1973 | 0 | ilo | Vietnam | 2005 | 1 | ipums |
| Lithuania | 1968 | 0 | eastfish | Yemen | 2005 | 1 | ilo |
| Madagascar | 2005 | 1 | ilo | Zambia | 2005 | 1 | ilo |
| Malawi | 2005 | 1 | ipums | Zimbabwe | 2005 | 1 | wdi |
| Malaysia | 1990 | 0 | gron | | | | |

Notes: YIT years for the full set of 149 countries. YIT refers to the year of industrial transition and is the

year in which employment in industry exceeded agriculture. It is based on the following sources: `ihs`: International Historical Statistics, Mitchell (2007); `gron`: Groningen Growth and Development Centre Total Economy Database, www.rug.nl/research/ggdc/; `ipums`: Integrated Public Use Microdata Series, www.ipums.org; `ilo`: International labor Organization, www.ilo.org; `wdi`: World Development Indicators, data.worldbank.org, `eastfish`: Easterly & Fischer (1994), `uk`: Shaw-Taylor & Wrigley (2012). `notindu2005` is a dummy equal to one if the country was not industrialized by year 2005.

A.2 Deindustrialization

16 countries in the sample experience deindustrialization over the period of analysis, listed in Table 4. We have ruled out instances where multiple industrializations occur within 10 years. In these cases, it is likely that the reversal occurs as a result of measurement error, short-run shocks or other fluctuations in the economy not related to the long-run process of industrialization. 9 of the 16 countries industrialized in the past only but are not industrialized today. Armenia, Cuba, Georgia, Kazakhstan, Romania, and Ukraine were either allies or members of the USSR. They all deindustrialized during the 1990s following the dissolution of the Eastern Bloc.

Table 4: 16 countries that deindustrialize

| Country | YIT | Earliest YIT |
|----------------|------------|---------------------|
| Argentina | 1954 | 1897 |
| Armenia | not indu | 1965 |
| Botswana | not indu | 1991 |
| Chile | 1986 | 1954 |
| Cuba | not indu | 1974 |
| Czech Republic | 1948 | 1930 |
| Georgia | not indu | 1984 |
| Iraq | not indu | 1984 |
| Jamaica | not indu | 1986 |
| Kazakhstan | not indu | 1968 |
| Mexico | not indu | 1981 |
| New Zealand | 1939 | 1902 |
| Romania | not indu | 1977 |
| Slovakia | 1948 | 1930 |
| Syria | 2004 | 1978 |
| Ukraine | 2001 | 1968 |

Notes: List of countries that have deindustrialized over the period. YIT is the year of industrial transition listed in Table 4. Earliest YIT is an alternative measure of YIT calculated as the earliest year in which employment in industry exceeded agriculture.

A.3 Appendix Figures

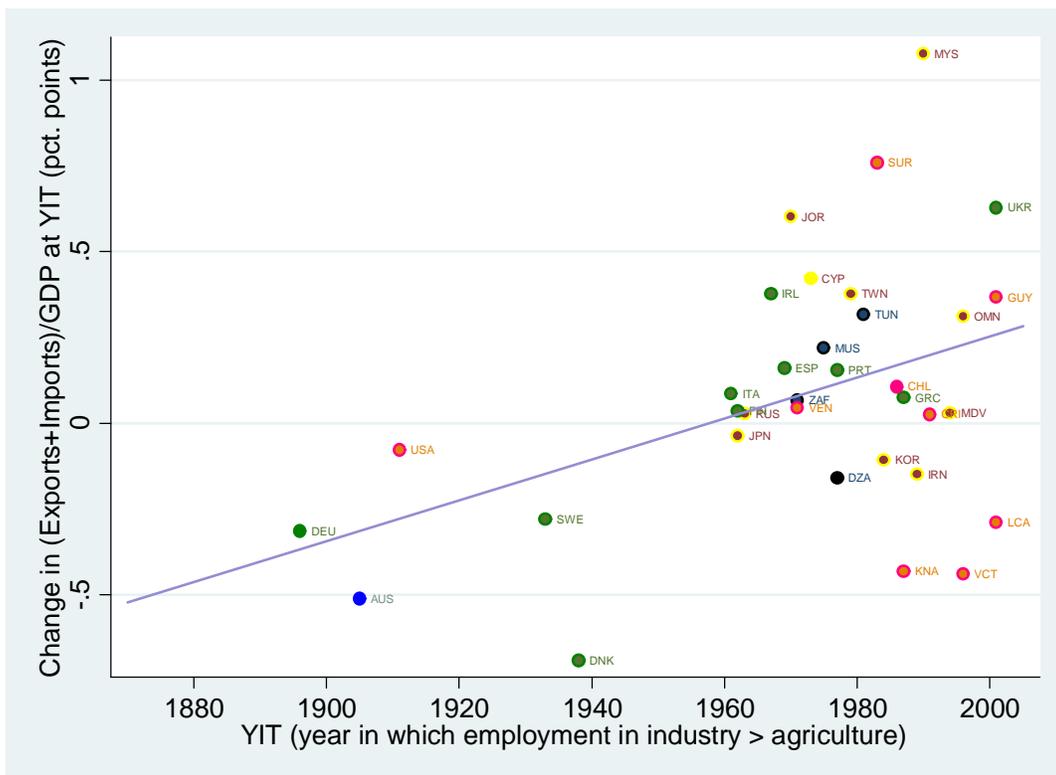


Figure 13: Simple plot of change in openness 10 years before to 10 years after YIT against YIT for 34 countries. The fitted grey line is the raw correlation between the two. The correlation coefficient is 0.42 (p-value = 0.01). Colour coding according to continents: Oceania (blue), Africa (black), Europe (green), Americas (red), and Asia (yellow). *Sources:* (Exports+Imports)/GDP: Penn World Tables and Mitchell (2007), YIT year: own calculations.

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