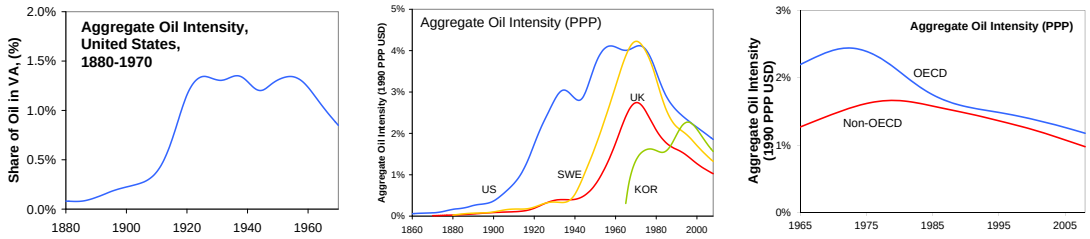
Online Appendix:
Structural Transformation and the Oil Price[1]

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1 Online Appendix



(a) USA (current)

(b) USA, Sweden, UK, S. Korea (PPP)

(c) Non-OECD and OECD

Figure 1: Aggregate oil intensity measured using constant oil price and 1990 PPP GDP.

Time Series Evidence I provide some evidence of a hump-shaped oil intensity within countries over time. One has to be cautious when interpreting this data due to the existence of confounding factors that may drive aggregate oil intensity over time, but are largely exogenous to the country such as the oil shocks in the 1970s and 1980s or the transition to different energy technologies. The US between 1880 and 1970 largely avoids the above pitfalls: its oil market was almost entirely closed[2] and relatively free of government intervention whilst oil had already been adopted as a viable energy source. Figure 1(a) shows that a hump-shaped aggregate oil intensity existed for US during this period. Another way to try to get around some confounding factors - like the volatile oil price post-1970 - is to use the constant price, PPP measure of oil intensity introduced above. Figure 1 shows oil intensities for the US (1860-2008), the UK (1870-2008), Sweden (1880-2008) and South Korea (1965-2008). A strong hump-shape pattern emerges in all cases. One can also re-do the same calculation for OECD and non-OECD countries for 1965-2008 - again we see a clear hump-shape pattern in non-OECD intensity and a roughly declining intensity over the period in the OECD. Nonetheless, we should be cautious about concluding too much from these time-series graphs. Whilst the aggregate intensity of different countries peaks at different times, there is a notable decline in intensity post-1970 which could be a consequence of the massive oil shocks of that period. Thus, whilst looking at time-series evidence is enlightening, the panel-data approach that control for time- and country-fixed effects is still preferable.

In the above, oil consumption (Table Db166) and nominal GDP data (Table Ca10) for the US comes from Carter et al., eds (2006). Historical oil consumption is denominated in British

[2] Pre 1970, 80-100% of US oil consumption was produced domestically. By 1980 this share was down to 50%.

	agrvaSh	agrvaShSq	mfgvaSh.	servaSh	servaShSq	logGDPpc	sqlogGDPpc
Agg. Int	0.061***	-0.126***	0.022***	0.092***	-0.114***	0.073***	-0.004***
	(0.006)	(0.011)	(0.004)	(0.015)	(0.015)	(0.003)	(0.000)
Time FE	yes		yes	yes		yes	
Obs.	2,053		1,884	2,049		2,186	
R^2	0.130		0.097	0.143		0.311	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1: Regressions of aggregate oil intensity versus shares of agricultural, manufacturing and service value added in total value added and log of GDP per capita (2005, PPP USD) and their squares.

Thermal Units (BTU). To convert the price of oil per barrel, into price per BTU I have used the estimated conversion factor of 5.8 million BTU's per crude barrel of oil as given by the EIA. Notice that this conversion is only an estimate and can vary over time and with type of oil. Historical oil consumption is also an estimate derived from trade data. As such, the levels of oil intensity found here should be taken with a grain of salt. Data for oil consumption before 1965 for Sweden comes from Kander and Lindmark (2004) and from Fouquet and Pearson (1998) for the UK. Oil consumption data for all countries and regions after 1965 comes from (BP, 2013). PPP measures of GDP come from Maddison (2007) with 1990 being the reference year. Oil price data in 1990 comes from BP (2013).

Alternative Measures of Structural Transformation Next, I consider alternative measures of structural transformation. Agricultural employment shares represent the preferred yardstick due to its widespread availability and simplicity, but none of the results hinge on this particular choice. Table 1 re-runs the regressions of Table **??** using value added shares of agriculture, manufacturing and services as well as log of PPP GDP per capita (in 2005 USD) as yardsticks of industrialization. All the results go through as before.[3]

Finally, notice that the model lends itself to a particular measure of structural transformation. Combining equations **??** and **??** and taking the ratio across countries gives the following relationship: $\frac{N^c_{s,t}}{N^w_{s,t}} = \left(\frac{w^c_t}{w^w_t}\right)^{\sigma_s - 1}$, which describes how changes in relative wages influence relative sectoral oil intensity. In a one sector model, this relation also describe the log-linear evolution of *aggregate* intensity with the relative wage. In Table 2 I regress aggregate oil intensity relative to OECD aggregate oil intensity on value added per capita relative to OECD value added per capita (and its square) for our baseline sample of countries. The results suggest the relationship is highly *non-linear* and follows a strong hump shape.

[3] Notice that I regress oil intensity versus manufacturing share and not by manufacturing share squared. This is because manufacturing tends to follow a hump-shape with structural transformation.

	Rel. Agg. Int	Rel. Agg. Int	Rel. Agg. Int	Rel. Agg. Int
logRelw	-0.683***	-0.673***	-0.914***	-0.894***
	(0.029)	(0.028)	(0.034)	(0.033)
logRelwSq	-0.106***	-0.107***	-0.026***	-0.034***
	(0.007)	(0.007)	(0.008)	(0.008)
Time FE	no	yes	no	yes
Country FE	no	no	yes	yes
Obs.	1,177	1,177	1,177	1,177
R^2	0.472	0.517	0.924	0.938

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2: Regressions of aggregate oil intensity (normalized by OECD intensity) on current price GDP per capita (normalized by OECD GDP per capita).

1.1 Total Factor Productivity

Ideally, I would calculate TFP as a residual directly from the data using the expression: $B^i_{s,t} = \frac{Y^i_{s,t}}{\left(\eta_s (g^E O^i_{s,t})^{\frac{\sigma_s-1}{\sigma_s}} + (1-\eta_s) L^i_{s,t}{}^{\frac{\sigma_s-1}{\sigma_s}}\right)^{\frac{\sigma_s}{\sigma_s-1}}}$, where $Y^i_{s,t}$ is a country i's sector s gross output, $O^i_{s,t}$ is its oil use and $L^i_{s,t}$ is its labor force. Data on sectoral oil use and gross output however, is available only for limited countries. Consequently, I estimate sectoral productivity growth data using labor productivity data which is given by $\bar{D}^i_{s,t} = \frac{V^i_{s,t}}{L^i_{s,t}}$, where $V^i_{s,t}$ is the value added of sector s in country i at time t in constant prices, calculated above. In the model, labor productivity is defined as:

$$D^i_{s,t}(B^i_{s,t}) \equiv \frac{p^i_{s,2005} B^i_{s,t} \left(\eta_s (g_E O^i_{s,t})^{\frac{\sigma_s-1}{\sigma_s}} + (1-\eta_s) L^i_{s,t}{}^{\frac{\sigma_s-1}{\sigma_s}}\right)^{\frac{\sigma_s}{\sigma_s-1}} - p^O_{2005} O^i_{s,t}}{L^i_{s,t}}, \tag{1}$$

where the term in the numerator is the value added of a sector s in country i at time t in 2003 prices (notice that this is just the gross output of sector s less intermediate inputs - the oil used in the sector). TFP levels, $B^i_{s,t}$, are chosen so that the model's implied labor productivity, matches observed labor productivity, i.e. $D^i_{s,t}(B^i_{s,t}) = \bar{D}^i_{s,t}$.

1.2 Trade Shares

Figure 2 plots the *aggregate*, constant price import consumption shares in the model and the data (WDI (2013)). In the non-OECD, the model captures the trend of the data although it overestimates trade initially and underestimates it in the second part of the sample. In the OECD the model does well in the second part of the sample matching both the trend and the

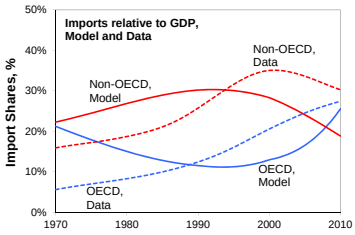
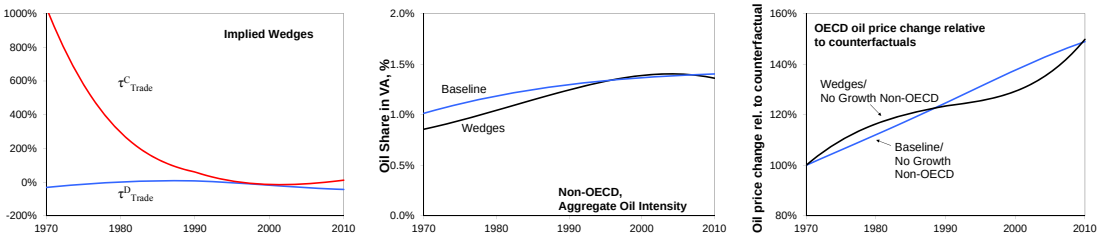


Figure 2: Import shares: Imports relative to GDP in data and model.



(a) Implied Wedges.

(b) Agg. Oil intensity the non-OECD

(c) Oil price rel. to model with zero growth in OECD.

Figure 3: Impact of different population growth rates.

level of trade, but overestimates trade shares initially. There are several reasons for the imperfect match. First, the model is calibrated to sectoral rather than aggregate trade flows (and only to that of the non-OECD at that). Second, I keep a symmetry in preferences across home and foreign goods in the model as there is no intrinsic reason to suspect that cross-country preferences over home and foreign goods vary systematically (ceteris paribus). As such, when faced with two very different trade patterns, there is only so much asymmetry that a fundamentally symmetric model can generate. Third, there is a large increase in global trade over this period that models far more sophisticated than mine have failed to match. Finally, the baseline model does not take into account the massive changes in non-OECD trade policy over this period (particularly in the non-OECD). With respect to the last factor, I can choose trade policies in the model that take the form of time-varying, country-specific wedges, τ_i for $i = C, D$, on all imported consumption goods to match each country's non-fuel import share, with all revenues being lump sum rebated to consumers. The results are shown in Figure 3. As expected, a massive opening up within the non-OECD is visible in the form of a decline of the wedge. The impact on intensity and prices is shown in panels (b) and (c) of the Figure and is minimal. The model predicts a slightly lower intensity in the non-OECD, but one that is qualitatively similar. The impact of the wedges on the price of oil relative to the zero-growth model is also negligible.

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