Government Misallocation and the Resource Curse[1]

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Abstract

Resource-rich countries tend to employ a higher proportion of workers in the government sector than resource-poor countries. I construct a model with a productive government sector and examine optimal government employment in resource-rich countries. In the calibrated best-case-scenario model, predicted optimal government employment in resource-rich countries is nearly 10 times smaller than in the data. This implicit misallocation has a large impact on welfare and aggregate productivity. Using the calibrated model I find that a ten percentage point increase in resource windfalls is associated with a 1.72% lower aggregate productivity and a 1.11% lower welfare arising from government misallocation.

[1] Thanks to Antonio Mele for useful discussion and comments. All errors are my own. Email: rls7@st-andrews.ac.uk.

1 Introduction

This paper investigates whether bloated public sectors drive the so-called 'resource-curse'. In particular I investigate the impact of structural transformation in an open economy on sectoral and aggregate productivity with a particular focus on the role of government. Structural transformation is a reallocation of labor across sectors. Whilst there are potentially many sources of structural transformation,[2] I focus on labor reallocation induced by a windfall of revenue. Furthermore, I concentrate only on windfall revenue arising from the export of natural resources (fuels, ores and metals), although the entire analysis is applicable to other types of windfalls such as - for example - foreign aid, remittances, EU structural funds or war reparations.

The exact focus here is the size of public sector employment in resource-rich countries. Governments provide largely non-traded services (such as law enforcement, defense, infrastructure, arbitration etc.) and thus we can expect the standard, "Dutch-Disease" mechanism pushing workers towards non-traded sectors in resource-rich countries to hold: higher windfalls of revenue should increase demand for both traded and non-traded goods, but since the supply of non-traded goods can only be provided locally, more workers need to shift to non-traded sectors - including the government sector - in order to satiate the higher demand for non-traded goods in resource-rich countries. As such, I am interested in how the size of public employment *should* vary optimally between resource-rich and resource-poor countries, whether the extent of government employment observed in resource-rich countries is efficient and - if not - what the productivity and welfare costs of this misallocation are.

I do two things in this paper. First, using a panel of macro cross-country data I demonstrate that the share of public sector employment is greater in resource-rich countries than in resource-poor countries - even controlling for the size of other non-traded sectors. Second, I construct and calibrate a small, open economy model with two production sectors and a government sector in which (optimally) higher government employment shares emerge as a consequence of windfall-induced labor reallocation. I then use a model to compare the optimal and observed size of government in order to obtain an estimate of the extent of government misallocation and the impact it has on welfare and productivity.

Importantly, the paper builds on earlier work by Kuralbayeva and Stefanski (2013). In that paper we did two things. First, we showed that resource-rich regions tend to have a) *small* but *relatively productive* manufacturing sectors and b) *large* but *relatively unproductive* non-manufacturing sectors. Whilst this difference in sectoral size (or Dutch-Disease effect) was well known and in line with theoretical predictions,[3] the productivity facts were novel and we

[2] Gollin et al. (2002), Duarte and Restuccia (2010), Rogerson (2008), Dekle and Vandenbroucke (2011) and Yi and Zhang (2010), for instance, focus on labor reallocation induced by non-homotheticities in agriculture.

[3] See for instance, Corden and Neary (1982), Matsuyama (1992) or Michaels (2011) for theoretical and empirical treatments of this so-called Dutch Disease.

showed that standard models were ill-equipped to replicate them. Second, we constructed and calibrated a small, open economy model with two sectors in which observed differences in sectoral productivity emerged endogenously as a consequence of windfall-induced labor reallocation and subsequent worker specialization. Since in the current paper I am interested in studying the impact of windfall-induced changes in government size on sectoral and aggregate productivity, it is crucial to correctly capture the windfall-induced changes in sectoral productivity that are *not* driven by changes in the size of the government sector. As such, in this paper I adapt the framework of Kuralbayeva and Stefanski (2013) which does well in reproducing the pertinent facts relating to both sectoral size and sectoral productivity in resource-rich countries in the absence of government.

More specifically, in my model, I assume that manufacturing consumption goods are traded whilst non-manufacturing consumption goods are non-traded and that agents have heterogeneous skills at performing different tasks in both consumption-good sectors. In addition, I assume the existence of government sector whose role it is to provide basic public services such as an institutional framework, law-enforcement, judiciary, defense, infrastructure etc. to the two consumption good sectors. The government sector is modeled as having a positive (external) effect on the productivity of both consumption sectors - however, government employees will have to be paid through a tax levied on all workers. I will also assume that government services cannot be imported from abroad. A region with higher windfall revenues will demand more of both consumption goods and of government services than a region without windfalls. Whilst the region's higher demand for manufacturing consumption goods can be satiated by imports from abroad, more workers need to be employed in non-manufacturing sectors (including the government sector) to meet the higher demand for locally produced non-manufacturing consumption goods and government services. This generates a reallocation of labor from manufacturing to the non-manufacturing sectors and results in a process of self-selection. Workers who choose to remain in manufacturing despite a windfall are those who are most skilled at manufacturing sector tasks, which leads to a more specialized and hence a more productive manufacturing sector. Workers who re-allocate to non-manufacturing do so only in response to the higher demand generated by the windfall and will be less skilled at non-manufacturing sector tasks than workers already employed in that sector. This can lead to a more de-specialized and hence less productive non-manufacturing sector.[4] Windfalls thus induce labor reallocation which in turn can generate asymmetric changes in sectoral productivity and an increase in the size of government.

I calibrate the model and show that the exogenous variation in endowments of natural resources does remarkably well in explaining the differences in sectoral employment structure and

[4] Although the extent of this de-specialization can be tempered by the higher productivity resulting from a bigger government - the exact pattern will depend on the particular calibration

the large, asymmetric differences in sectoral productivity observed across countries. The model also does well in explaining differences in non-manufacturing prices in the data. However, the optimal increase in government employment in resource-rich countries predicted by the model is significantly smaller than the employment observed in the data. Resource-rich countries seem to employ far more workers in government than the above model would suggest is optimal. In order to calculate the cost of this apparent misallocation, I feed in observed government employment levels into my model, and examine the subsequent changes in labor reallocation across manufacturing and non-manufacturing sectors and the resultant differences in productivity. I find that a ten percentage point increase in resource windfalls is associated with a 1.72% percent lower aggregate productivity and a 1.11% lower welfare arising from government misallocation. In short, resource-rich countries tend to have governments that are too big, and this can have a relatively large impact on both productivity and welfare.

The above idea of a negative relationship between natural resources and economic outcomes ties into the so-called “resource curse” literature - see for example Neary (1978), van der Ploeg (2010), Robinson et al. (2006), Collier and Goderis (2009), Collier and Hoeffler (2005) etc. Whilst the conclusions of that literature are not definitive, there is strong evidence to suggest that resource windfalls can generate various negative economic effects especially in the presence of bad governance and poor institutions. In particular, in that literature, negative economic outcomes are often a consequence of a corrupt political process associated with higher resource wealth. In short, those papers tend to argue that resource-rich countries offer more opportunities for graft which introduces a drag on the economy. The approach taken in this paper is different and intentionally complementary. In the model, I take the most charitable view of government possible. First, I assume that the government sector is a crucial input in production and that there is no corruption, no directly wasted resources, no electioneering, no graft and no costly power struggles. Second, governance in resource-rich countries is assumed to be potentially just as effective as in resource-poor countries. Finally, I assume that all tax revenues are raised via non-distortive lump-sum taxes. Thus, I do my best to give governments in resource-rich countries the benefit of the doubt and as such my model aims to generate the largest possible optimal increase of government employment in response to windfalls. In my setup, the only way that government can be inefficient is if it employs too many or too few workers relative to what is predicted optimal by the model. Importantly, however, I do not take a stand on *why* governments are the size that they are and instead - in my baseline experiment - I simply take public sector employment from the data and analyze the implicit misallocation costs of governments that are too big or too small.

Like Kuralbayeva and Stefanski (2013), the self-selection aspect of this work is in the spirit of Lagakos and Waugh (2012), Roy (1951) and Lucas (1978) and is closely linked to a similar discussion in the development literature. Poorer countries tend to have a larger fraction of their labor force employed in agriculture, due to subsistence requirements. Caselli (2005) and Restuccia et al. (2008) also show that productivity differences in agriculture between rich and poor countries are significantly greater than aggregate productivity differences. Lagakos and Waugh (2012) argue that this fact stems from the specialization that takes place in the smaller agricultural sectors in rich countries. They formalize and test their idea in the framework of a Roy (1951) model of self-selection. The outcomes of the above models however are efficient and do not consider the impact of a misallocation stemming from suboptimal government size. Furthermore, Lagakos and Waugh (2012) rely on non-homothetic preferences and an exogenous variation in aggregate productivity to generate a shift of workers across sectors. The current model has homothetic preferences and instead emphasizes the role of exogenous resource windfalls and the existence of a non-traded sector as the channel driving labor reallocation. Thus I avoid what Lagakos and Waugh (2012) call the "key challenge" of their setup which is the requirement of large, exogenous productivity differences to drive workers across sectors.

Section 2 introduces the data used in this study and establishes the productivity and employment facts. Section 3 introduces a general version of the model whilst section 4 considers the role of heterogeneity and government in a simple version of the model. Sections 5 and 6 present the solution and calibration of the general model, section 7 presents the results whilst section 8 delves into the scope of the government misallocation and its impact on productivity and welfare. Finally, I conclude in section 10.

2 Data and Facts

In this section I briefly review the data and facts pertaining to manufacturing and (non-resource) non-manufacturing employment shares and productivity constructed in Kuralbayeva and Stefanski (2013). I also examine the data and facts pertaining to employment in the government sector. In particular, I show that 1) resource-rich regions have small and relatively productive manufacturing sectors, 2) large and relatively unproductive non-manufacturing sectors and 3) a greater proportion of workers employed in the government sector.

Throughout, I follow Kuralbayeva and Stefanski (2013) and divide economies into mining and utilities (MU), manufacturing (M) and non-resource non-manufacturing (NM) sectors:[5]

$$\text{Total Economy} = \overbrace{\underbrace{A + C + S + G}_{\text{Non Res. Non-Mfg.}} + \underbrace{M}_{\text{Mfg.}}}^{\text{Non-Resource Economy}} + \underbrace{MU}_{\text{Mining and Utilities}}. \quad (1)$$

[5] The lowest level of aggregation available for all data is the one sector ISIC classification. NM here is defined as the sum of agriculture (A), construction (C), (private) services (S) and Government (G).

As in Kuralbayeva and Stefanski (2013), I focus only on the productivity and employment structure of the non-resource economy.[6] Diverging from Kuralbayeva and Stefanski (2013) however, I will also consider the proportion of non-manufacturing workers employed in the public sector. Notice, however, that I will not say anything about productivity in the government sector. Constructing sectoral productivity measures is challenging and the assumptions needed to calculate government-specific productivity would be heroic to say the least. In what follows I give a brief overview of the data.

Data In Kuralbayeva and Stefanski (2013) we considered three different measures of productivity for the manufacturing and non-manufacturing sector. We begin with labor productivity, then add sectoral physical capital and finally include sectoral human capital. In principle, each subsequent measure of TFP is better than the last, since it controls for a greater variety of factor inputs. In practice, each measure requires additional data that is often hard to come by and as such has to be estimated. Considering all three measures gives a better overall picture of sectoral productivity. However, when we examine the results and compare the changes of sectoral productivity with respect to resource wealth, we find quantitatively and qualitatively very similar results across all three measures. As such, in this paper, to save space and since that was the baseline measure chosen in the original paper, I will only consider the most comprehensive measure of productivity from that paper, D_s, obtained as a residual from the following production function:

$$Y_s = D_s(K_s)^{\alpha_s}(h_s L_s)^{1-\alpha_s} \tag{2}$$

where Y_s is sector s's value-added, L_s is sectoral employment, K_s is sectoral physical capital and h_s is average sectoral human capital, so that $h_s L_s$ is the 'quality adjusted' workforce.[7] Constant price sectoral value-added data comes from the UN, and is adjusted to control for cross-country sectoral price level differences using the World Bank's 2005 International Comparison Program (ICP) price data. Employment data comes from the ILO and physical capital is constructed using the perpetual inventory method from the PWT. I follow Caselli (2005) in constructing aggregate human capital from the Barro and Lee (2010) education data set and in constructing sectoral physical capital. Finally, due to lack of data, I assume that the ratio of human capital between any two sectors is constant across countries and time and equal to the corresponding ratio in the US and that labor shares in the last two measures of productivity, $1 - \alpha_s$, are identical across countries, constant over time and equal to OECD averages. For construction details, see the Appendix of Kuralbayeva and Stefanski (2013).

[6] Thus, when we refer to aggregate productivity or sectoral employment share, we always mean aggregate productivity of the *non-resource* economy or sectoral employment relative to *non-resource* employment.

[7] I also refer to D as the corresponding measures of aggregate (non-resource) productivity.

	(1) E Res./ GDP	(2) Output/ worker	(3) Emp. NM	(4) Share M	(5) Emp. G	(6) Share NG	(7) TFP NM	(8) (D_s) M
10^{th}%-ile	0.17	30,716	0.86	0.14	0.25	0.75	0.94	1.37
90^{th}%-ile	0.00	17,756	0.81	0.19	0.17	0.83	0.98	1.11
$10^{th}/90^{th}$			1.06	0.73	1.48	0.90	0.96	1.24

Table 1: Resource export share, output per worker, composition of employment (manufacturing vs. non-manufacturing and public vs. non-public) and a measure of sectoral productivity (relative to aggregate productivity) for top and bottom 10% of natural resource exporters. Data for 33 countries, for 1980-2007. (Source: see Section 2)

Next, I obtain public sector employment data from the ILO which "covers all employment of (the) general government sector as defined in System of National Accounts 1993 plus employment of publicly owned enterprises and companies, resident and operating at central, state (or regional) and local levels of government. It covers all persons employed directly by those institutions, without regard for the particular type of employment contract."[8]

I follow Sachs and Warner (2001) and Kuralbayeva and Stefanski (2013) in defining natural resource "wealth" as the ratio of exports of natural resources (fuels, ores and metals) to GDP using WDI data.

In my baseline sample, like in Kuralbayeva and Stefanski (2013), I consider a panel of the 120 richest countries for the years 1980-2007 period.[9] I keep all country-date points for which I have all necessary data and those that do not deviate significantly across different data sources. This leaves me with a total of 33 countries in my sample. On average, there are 10 observations for each country, 22 observations for each year and a total of 340 data points. Notice that until 1995, the data for public employment is only available once every five years and there are very few observations from 1980 and 1985.

Summary of Facts Table 1 shows summary results by comparing the largest 10 percent of natural resource exporters with the smallest 10 percent. The table reproduces the results (pertaining to sectoral size and productivity) found in Kuralbayeva and Stefanski (2013) for the current sample of data and adds the new finding pertaining to the size of government employment

[8] A limited subset of the public employment data is provided at the ISIC one sector level and in that (very limited) subset, public employment is overwhelmingly in the non-manufacturing sector. As such in the baseline experiment of this paper - in order to maintain as large a sample of data as possible - I shall assume that all government employment belongs entirely to the non-manufacturing sector.

[9] I focus on richer countries for three reasons: First, I am examining more disaggregate data than is standard so data quality in poorer countries is a serious concern. Second, the mechanism of specialization described later may play a more prominent role in richer countries. Finally, focusing on richer countries may avoid the worst of unobserved cross-country heterogeneity. Since this procedure may in principle result in unobserved selection bias, I have also experimented with a complete sample and the results are independent of this cutoff.

	(1)	(2)	(3)	(4)
	M. Emp.	$\log(D_m)$	$\log(D_s)$	$\log(p_s)$
log(NRE)	-0.014***	0.068***	-0.012***	0.048***
	(0.002)	(0.014)	(0.002)	(0.011)
logLprod	0.650***			
	(0.127)			
sqlogLprod	-0.031***			
	(0.006)			
log(D)		1.458***	0.888***	0.838***
		(0.078)	(0.011)	(0.067)
τ_e				-0.355***
				(0.132)
Time FE	yes	yes	yes	yes
Obs.	340	340	340	340
R^2	0.256	0.567	0.953	0.480

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

Table 2: Baseline results from Kuralbayeva and Stefanski (2013) in current sample of data.

in resource-rich countries. The table shows the decomposition of employment according to manufacturing/non-manufacturing and public/non-public sectors. Furthermore it also shows the sectoral productivity (in manufacturing and non-manufacturing) normalized by aggregate productivity of each group. From the table observe that resource-rich countries: 1) employ proportionally 27% less workers in manufacturing (column 4) and 6% more workers in (non-resource) non-manufacturing (column 3) than resource-poor countries and 2) that they are 24% more productive in manufacturing (column 8) and 4% less productive in non-manufacturing (column 7) relative to aggregate productivity than resource-poor countries. Finally, also notice that resource-rich countries: 3) employ 48% more workers in the public sector (column 5) and 10% less workers in the non-public sector (column 6) than resource-poor countries.

As in Kuralbayeva and Stefanski (2013), I stress that the productivity results refer to *relative* and *not absolute* productivity. So, for example, looking at the column labeled D_m (column 8) in Table 1, the average productivity of manufacturing in the top 10% of resource exporters is 37% higher than the average aggregate productivity of those same countries, whereas in the bottom 10% of exporters the average manufacturing productivity is only 11% higher than the average aggregate productivity in that group of countries. Countries that have low aggregate (or sector neutral) levels of productivity will have low *absolute* levels of productivity in all sectors irrespective of the size of their resource endowments but may still have high productivity in manufacturing *relative* to their aggregate productivity.

Earlier Results In this section in Table 2, I briefly reproduce the baseline regressions of Kuralbayeva and Stefanski (2013) for the current sample of data. For robustness with respect to these regressions and further discussion see that paper. Column (1) shows the regression of manufacturing employment share on the log of the windfall measure controlling for changes in output per worker (and output per worker squared) as well as controlling for time-fixed effects.[10] Resource-rich countries employ less workers in the manufacturing sector and (implicitly) more workers in the non-manufacturing sector: a doubling of resource windfalls is associated with a 1.4 percentage point decline in the manufacturing employment share. These results are statistically significant at the one percent level.

Columns (2) and (3) of Table 2 show how (the log of) manufacturing and non-manufacturing productivity varies with (the log of) resource windfalls and aggregate productivity. Higher aggregate (or sector neutral) productivity is unsurprisingly associated with higher sectoral productivity. However, controlling for differences in aggregate productivity, resource-rich countries tend to be more productive in manufacturing and less productive in non-manufacturing than resource-poor countries. These results are significant at the one percent level and are robust to other measures of productivity as discussed in Kuralbayeva and Stefanski (2013). A doubling of natural resource windfalls is associated with a 1.2% lower non-manufacturing productivity and a 6.8% higher manufacturing productivity.[11]

An important fact that will be examined later, is the positive impact of windfalls on the non-manufacturing price. In Kuralbayeva and Stefanski (2013) we constructed a panel of sectoral price level data by combining ICP cross-country sectoral price levels with sectoral price indices from the UN. Column (4) reproduces the baseline price regression from Kuralbayeva and Stefanski (2013). In particular it shows the regression of the log of relative non-manufacturing price levels (with respect to manufacturing price levels) on the (log) measure of resource windfalls, (log) aggregate productivity, energy subsidies from WEO[12] and time-fixed effects.[13] I

[10] Since employment share in manufacturing is simply one minus the employment share in non-manufacturing, the regressions for non-manufacturing employment are the same with opposite signs on coefficients. As in Kuralbayeva and Stefanski (2013), I take a log transformation of resource windfalls since the data is concentrated near zero. This ensures that the transformed empirical distribution is closer to normal. Importantly this transformation does not drive the results. Finally, I control for output-per-worker and output-per-worker squared since it is a well established fact that manufacturing follows a hump shape with income. This in no way drives my results. For details and robustness tests, see Kuralbayeva and Stefanski (2013).

[11] I emphasize that these results refer to *relative* and *not absolute* productivity. Countries that have low aggregate (or sector neutral) levels of productivity will have low *absolute* levels of productivity in all sectors irrespective of the size of their resource endowments but may still have high productivity in manufacturing *relative* to aggregate productivity.

[12] Subsidy data is an average of 2008-2010 data. We assume that these subsidies are country specific and fixed over the 1980-2007 period.

[13] Notice that we included aggregate productivity to control for the so-called Penn effect - the observation that richer countries have higher non-traded goods prices than poorer countries. Furthermore, as was discussed in Kuralbayeva and Stefanski (2013) a potential issue with the ICP price data is that they reflect consumer rather than producer prices - which are the focus of the later model. This may be particularly important in resource-rich economies, where consumer subsidies are prevalent. We control for energy subsidies as an indirect

	(1)	(2)	(3)	(4)	(5)
	G. Emp.	G. Emp.	G. Emp.	G. Emp.	G. Emp.
log(NRE)	0.014***	0.017***	0.011***	0.013***	0.021***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
logLprod			0.041***	0.045***	0.045***
			(0.008)	(0.008)	(0.008)
NM. Emp.					-0.595***
					(0.103)
Time FE	no	yes	no	yes	yes
Obs.	340	340	340	340	340
R^2	0.045	0.061	0.115	0.139	0.220

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

Table 3: Changes in government employment share and resource wealth.

find that a doubling of natural resource windfalls is associated with a 4.8% increase in the price of non-traded goods and these results are significant at the one percent level.

Public Sector Employment Results Next, I present the novel empirical results of this paper. Table 3 shows the regressions relating the size of the government sector employment with resource windfalls. In particular, column (1) shows the regression of government employment share on the log of my windfall measure. Resource-rich countries employ more workers in the public sector and (implicitly) less workers in the non-public sector. These results are statistically significant at the one percent level. Column (2), controls for time fixed effects, whilst column (3) controls for changes in output per worker which may help reduce unobserved cross-country heterogeneity. Column (4) adds time-fixed effects to the regressions in column (3). In all three cases, the results remain largely unchanged. Finally, column (4) adds employment shares of the non-manufacturing sector. The results of this last regression tells us that - even controlling for the size of other non-manufacturing sectors - resource-rich countries tend to have a larger government sector. Taking column (2) as the baseline result, I find that a doubling of natural resource windfalls is associated with a 1.7% higher public sector employment share and these results are significant at the one percent level.

Finally, notice that whilst in Kuralbayeva and Stefanski (2013) we controlled for time and country-fixed effects, in the above regressions I include only time-fixed effects. There are two reasons for this. First, I have a far more limited sample of data and so there is not enough variation over time in the sample. Most of the variation over time in windfalls comes from variation in price which tends to be common across countries. Since much of the price variation

attempt at controlling for the overall level of subsidies in a country's economy in natural resources took place in the 1980's and much of our public employment data is missing in that period, there is very little temporal variation in the remaining data.[14] Second, and perhaps more importantly, the focus of this paper will be government employment. This type of work is often characterized by tenure or unionization and is thus often quite unresponsive to shocks over time - at least in the short run. As such, to examine the persistent effects of resource endowments, it makes more sense to look at cross-country differences which can be interpreted as long run effects.

3 Model

In this section I introduce a small, open, multi-sector economy with heterogenous agents that can account for the observed facts in productivity and employment. The model closely follows Kuralbayeva and Stefanski (2013), but introduces a role for government. There are three final goods in the economy: manufacturing goods (m), private non-manufacturing goods which - for brevity - I will call services (s) and a windfall good which, also for brevity, I will refer to as oil but could equally well be any other natural resource or alternative source of windfall revenue. I assume that manufacturing and oil are traded internationally, whilst services are assumed to be non-traded. Oil is assumed to be an endowment good that is not used locally but only exported abroad (and thus serves as a windfall of income), whilst manufacturing and services can be produced locally using labor but no oil. I also assume the existence of a government sector (the public non-manufacturing sector) which provides the manufacturing, service and oil sectors with inputs such as institutional frameworks, transportation, rule of law, arbitration etc. that are productivity enhancing, but are external to firms (and workers). Thus, whilst workers can be employed in the government sector, the sector produces no final goods directly, but rather provides an input that looks like a higher level of productivity to other sectors of the economy. Finally, I assume that the external benefits produced by government cannot be imported from abroad.

Households Suppose there is a measure one of agents, indexed by i. Preferences are given by:

$$U(c_s^i, c_m^i) \equiv \left((c_s^i)^{\frac{\sigma-1}{\sigma}} + \nu (c_m^i)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \tag{3}$$

Each agent in the economy is endowed with a unit of time and assumed to have a vector of innate sector specific skills or talents, $\{z_s^i, z_m^i\}$, representing the efficiency of that unit of time

[14] A rule of thumb here is to regress the independent variable - $\log(NRE)$ - on country fixed effects. If the value of $1/(1-R^2)$ from the resulting regression is less than ten, the rule of thumb suggests that there is enough variation in the data to include that variable. In our case $1/(1-R^2) = 11$ thus suggesting there is too little variation to include country fixed effects.

in the service sector (s) and the manufacturing (m) sector. Endowments of skills $\{z_s^i, z_m^i\}$ are exogenous and are assumed to be randomly drawn from a distribution common to the whole population $N(z_s, z_m)$. Since skills are assumed to be perfectly observable, agents earn a wage income, w^i. The agent is also endowed with a resource tree that provides a stream of O units of oil each period. Oil is not directly used by the agent but is exported and provides windfall revenues. Finally, each agent also potentially faces a lump-sum tax, T, paid to government. The budget constraint of the agent is thus given by:

$$p_s c_s^i + c_m^i \leq w^i + G_o(Y_g) p_o O - T, \tag{4}$$

where, p_s is the relative price of service sector goods and p_o is the relative price of oil determined on international markets. Traded manufacturing goods are taken as numeraire. Finally, in the above, $0 \leq G_o(Y_g) \leq 1$ is a function capturing the external productivity benefits of government to the export of oil. These are assumed to be positively dependent on the output size of the government sector, Y_g. I describe this function in more detail in the following paragraphs.

Production I assume a competitive market in all final good sectors so that each worker gets paid his marginal product. The output of worker i in sector $k = s, m$ is given by $Y_k^i = AG_k(\cdot) z_k^i$, where A is aggregate (potentially sector specific) efficiency, z_k^i is the worker's sector specific productivity and $0 \leq G_k(\cdot) \leq 1$ is the impact of government on productivity that is external to workers and firms but depends positively on the size of government employment, L_g, in a manner described in the following paragraph. Aggregate output in sector $k = s, m$ is given by:

$$Y_k \equiv \int_{i \in \Omega^k} Y_k^i di = AG_k(Y_g) \tilde{L}_k, \tag{5}$$

where Ω^k is the set of agents electing to work in sector k, $L_k \equiv \int_{i \in \Omega^k} di$ is the number of workers in private enterprises in sector k and $\tilde{L}_k \equiv \int_{i \in \Omega^k} z_k^i di$ represents the total effective labor units (privately) employed in sector $k = s, m$.

Trade It is assumed that manufacturing goods and oil are traded whilst service sector goods are not traded. In order to close the model, I assume a period-by-period balanced budget constraint given by:

$$m - G_o(Y_g) p_o O = 0, \tag{6}$$

where, m is the value of imported traded goods (recall that traded goods are assumed to be the numeraire) and $G_o(L_g)$ is the impact of government on how effective imports are, capturing the idea of a type of iceberg transport cost. Finally, in the above setup, all oil endowments are exported in exchange for manufacturing imports. A country with no oil (i.e. $p_o O = 0$) is thus assumed to be closed to trade.

Government The government's role is to provide output sectors with public goods and services such as infrastructure, a justice system, law and order etc. that enhance their sectoral productivity. Total government output of public goods and services is denoted by Y_g. This level of government output enhances sectoral productivity according to the function $G_k(Y_g)$:

$$G_k(Y_g) = 1 - \frac{\psi^k}{\psi^k + Y_g}. \tag{7}$$

In the above $\psi^k \geq 0$ is a constant capturing the importance of government services to production in a particular sector. If $\psi^k = 0$, then $G_k(Y_g) = 1$ and the model collapses to the no-government world of Kuralbayeva and Stefanski (2013). When $\psi^k > 0$, $G'(Y_g) > 0$ - that is higher levels of government output contribute more - ceteris paribus - to the productivity of output sectors. If no government output is produced, (i.e. $Y_g = 0$) this implies that $G_k(0) = 0$ and hence output in *all* sectors is zero. Consequently, with $\psi^k > 0$, positive output in government is necessary for any production to take place.

Government produces output, Y_g, by employing a set of workers Ω^g to produce public goods and services. Notice that the total number of workers employed by government is thus given by, $L_g \equiv \int_{i\in\Omega^g} di$. The output of a worker i employed in the government sector, $i \in \Omega^g$, is given by

$$Y_g^i = AG_g(Y_g)(z_s^i)^\alpha (z_m^i)^{1-\alpha}, \tag{8}$$

where A is economy-wide aggregate efficiency, z_k^i is a worker's sector specific ability in sectors $k = m, s$ and the term $0 \leq \alpha \leq 1$ is the weight of each type of ability in government output. Thus, a worker in government - unlike in the two sectors - will potentially make use of both abilities in their work for the government.[15] However, as in the private sector, output of government workers also depends on external productivity benefits of government through the term $G_g(Y_g)$. Thus the benefits of good governance apply to producers in the public sector just as they do to producers in the private sector. Aggregate output of the government sector is then given by summing over the output of all agents employed by the government:

$$Y_g \equiv \int_{i\in\Omega^g} Y_g^i di = AG_g(Y_g)\tilde{L}_g, \tag{9}$$

where $\tilde{L}_g \equiv \int_{i\in\Omega^g} (z_s^i)^\alpha (z_m^i)^{1-\alpha} di$ represents the total effective labor units employed in the government sector g. This output then enhances sectoral productivity according to equation (7) above. Importantly I assume that government workers take their own contribution to government output as exogenous.

[15] An alternative way to think of this is that each worker is endowed with a unit of time that he can split between s and m abilities and that output of a worker in government is given by $\bar{Y}_g^i(\delta) \equiv AG_g(Y_g)\frac{1}{\alpha}(\delta z_s^i)^\alpha((1-\delta)z_m^i)^{1-\alpha}$. Since workers are paid per effective unit of labor, they will want to maximize their supply of effective labor. To do so they will choose $\delta = \alpha$, and so $\bar{Y}_g^i(\alpha) = Y_g^i$.

Taking the expression for $G_g(Y_g)$ from equation (7), substituting it into (9) and assuming that $Y_g > 0$ it is easy to show that $Y_g(\tilde{L}_g) = A\tilde{L}_g - \psi^g$ and hence that we need $\tilde{L}_g > \frac{\psi^g}{A}$ for government output to be positive. The parameter ψ^g captures the minimum (productivity adjusted) effective labor needed in government so output will be produced. Taking this expression and substituting it into 7 we obtain an explicit expression for G_k in terms of effective labor only:

$$G_k(Y(\tilde{L}_g)) = 1 - \frac{\psi_k}{(\psi_k - \psi_g) + A\tilde{L}_g}. \tag{10}$$

Finally, I assume that government pays the same wage, w_g for each unit of effective labor that any agent supplies. Thus, an agent i working in government will earn a wage w_g^i, given by $w_g^i = w_g A G_g(Y_g)(z_s^i)^\alpha (z_m^i)^{1-\alpha}$. As such, the government's budget constraint, which is assumed to be balanced period by period, is given by:

$$T = w_g A G_g(Y_g)\tilde{L}_g. \tag{11}$$

Thus, the government levies a per period lump-sum tax on each worker to pay for the wages of all its employees.

Market Clearing Defining $\Omega = \Omega^m \bigcup \Omega^s \bigcup \Omega^G$, the market clearing conditions for manufacturing, services and employment are given by:

$$\int_{i\in\Omega} c_m^i di = Y_m + m \text{ and } \int_{i\in\Omega} c_s^i di = Y_s \text{ and } L_m + L_s + L_g = 1. \tag{12}$$

Competitive Equilibrium For each price of oil, p_o, every endowment level of oil O, and for a given size of government L_g, equilibrium in the above economy consists of a relative price of service goods, p_s, agent-specific wages w^i and allocations for all agents, firms and government so that labor and output markets clear, and trade as well as the government budget constraint remains balanced, period by period.

Solution Each manufacturing and service sector firm chooses a non-negative quantity of labor to hire. Due to perfect competition, firms offer the following wage schedule to consumer i:

$$w_m^i = AG_m(Y_g)z_m^i \text{ and } w_s^i = p_s AG_s(Y_g)z_s^i, \tag{13}$$

in manufacturing and service sectors respectively whilst - as explained above - wage offers in the government sector are given by:

$$w_g^i = w_g AG_g(Y_g)(z_s^i)^\alpha (z_m^i)^{1-\alpha}. \tag{14}$$

Consumer i will choose to work in the sector that provides the highest wage given his particular ability endowment. The wage offer for each worker will thus be given by, $w^i = \max\{w_s^i, w_m^i, w_g^i\} =$

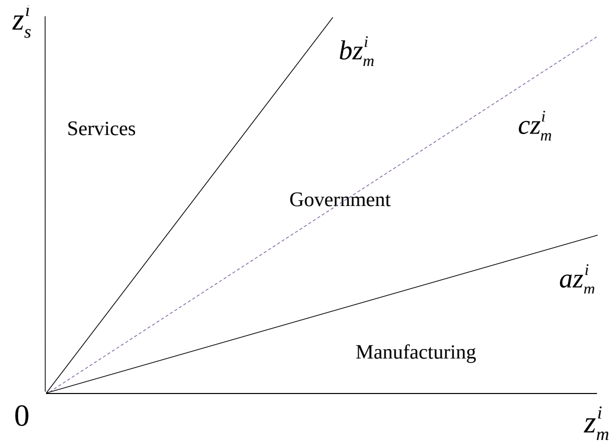


Figure 1: A worker's decision problem. In the above $a \equiv \left(\frac{G_m(\cdot)}{G_g(\cdot)w_g}\right)^{1/\alpha}$, $b \equiv \left(\frac{G_g(\cdot)w_g}{G_s(\cdot)p_s}\right)^{1/(1-\alpha)}$ and $c \equiv \frac{G_m(Y_g)}{G_s(Y_g)p_s}$.

$\max\{p_s A G_s(Y_g) z_s^i, A G_m(Y_g) z_m^i, w_g A G_g(Y_g)(z_s^i)^\alpha (z_m^i)^{1-\alpha}\}$. This gives rise to the following simple cut-off rules: a worker i will choose to work in services if and only if

$$z_s^i > c z_m^i \text{ and } z_s^i > b z_m^i, \tag{15}$$

in manufacturing if and only if

$$z_s^i < c z_m^i \text{ and } z_s^i < a z_m^i, \tag{16}$$

and in government if and only if

$$a z_m^i \leq z_s^i \leq b z_m^i, \tag{17}$$

where $a \equiv \left(\frac{G_m(Y_g)}{G_g(Y_g)w_g}\right)^{\frac{1}{\alpha}}$, $b \equiv \left(\frac{G_g(Y_g)w_g}{G_s(Y_g)p_s}\right)^{\frac{1}{1-\alpha}}$ and $c \equiv \frac{G_m(Y_g)}{G_s(Y_g)p_s}$. If we assume that each sector has positive employment, then it is easy to show that $a \leq c \leq b$ (see the Appendix for a proof), and the above cut-off rules for manufacturing and services sectors workers simplify so that a worker i chooses to works in services if and only if

$$z_s^i > b z_m^i, \tag{18}$$

and in manufacturing if and only if

$$z_s^i < a z_m^i. \tag{19}$$

Thus worker's decision rules are given by equations 17 -19. This is illustrated in Figure 1, which shows all the potential combination of individuals' ability draws and the cut-off conditions specifying in which sector an individual with particular set of abilities will choose to work.

Agents take as given prices as well as the wage offers arising from the firm and government problems (and hence the above decision rules). Having picked their specialization, they then proceed to maximize (3) subject to (4), which results in the following demands of each agent:

$$c_s^i = \frac{(w^i + G_o(Y_g)p_oO - T)}{p_s + \nu^\sigma p_s^\sigma} \text{ and } c_m^i = \frac{\nu^\sigma p_s^\sigma (w^i + G_o(Y_g)p_oO - T)}{p_s + \nu^\sigma p_s^\sigma}. \tag{20}$$

Using the goods market clearing conditions in equation (12) and the demands of each agent from equations (20), I can show that:

$$\nu^\sigma p_s^\sigma Y_s = Y_m + G_o(Y_g)p_oO \tag{21}$$

Substituting (5) into (21), provides an implicit expression for p_s as a function of the value of oil endowment, p_oO and the level of government employment.[16]

Observed and Optimal Government In this paper I consider two ways of setting government employment. First, I will assume government employment is exogenous and taken directly from the data. In this case, government sets its wage offers just high enough to match observed government employment in the data. Second, I will suppose that government employment emerges from choices of a benevolent social planner who wishes to maximize the utility of workers. In particular, a benevolent government will take the demand functions of agents (derived above in equations (20)) as given and solves a Ramsey-type problem for the optimal government wage, w_g^{opt}, by maximizing the expected utility of workers:

$$\max_{w_g^{opt} > 0} \mathbb{E}_{\gamma_i}(U(c_s^i(w_g), c_m^i(w_g))), \tag{22}$$

where $\mathbb{E}_{\gamma_i}(U(c_s^i, c_m^i)) = \int_0^1 \gamma_i U(c_s^i(w_g), c_m^i(w_g))di$. In this expression, $\gamma_i : \mathbb{R} \to \mathbb{R}$ is a function that specifies the weight that a government places on individual i. If $\gamma_i = 1$, as it will be in our baseline, the government cares equally about every individual. In Appendix 12, I consider the case when different agents have different weights. The optimal wage w_g^{opt}, then implies an optimal level of government employment L_g^{opt}.

4 A Simple Example

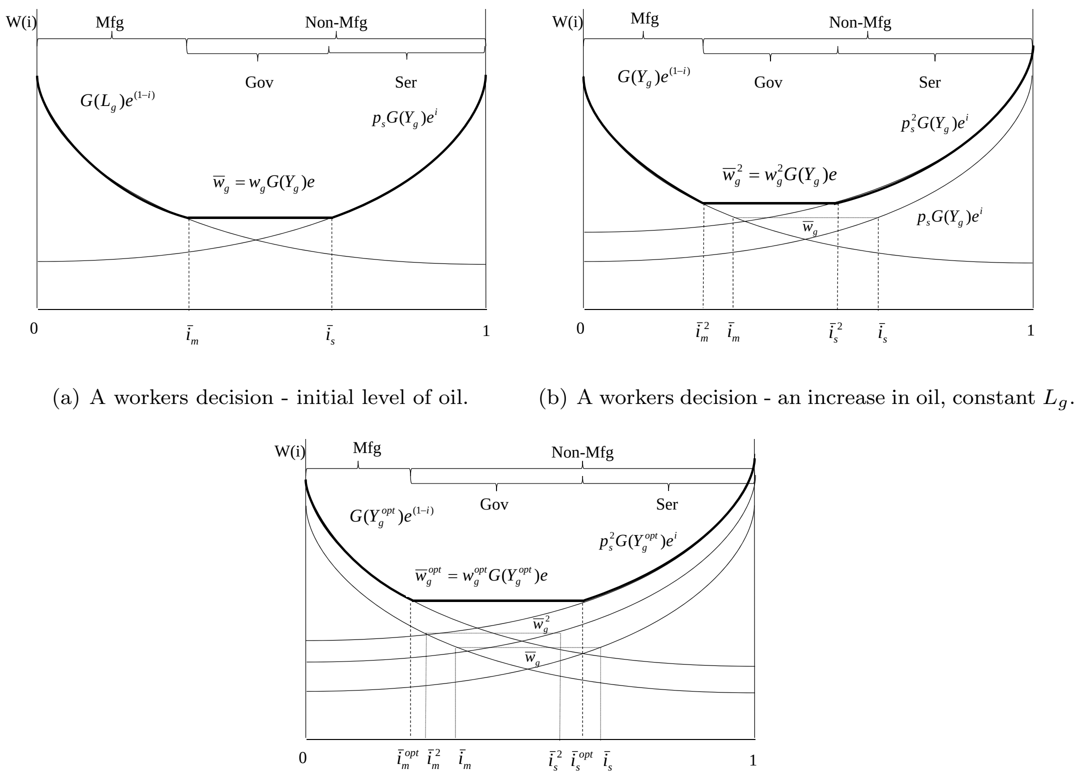
To illustrate the impact of worker heterogeneity and government on sectoral productivity, I begin with a simple example.[17] Suppose the skill distribution N is degenerate and given

[16] Notice that I have assumed that windfall income are distributed evenly across agents. This assumption plays no role in our results since equation (21) (and hence the equilibrium price and cutoff condition) holds regardless of how windfalls are distributed.

[17] Whilst I focus on heterogenous workers, this setup can easily be related to one with heterogenous firms without changing the results.

by $\{z_s^i, z_m^i\} = \{e^i, e^{1-i}\}$ for each worker $i \in [0,1]$. Furthermore, assume Cobb-Douglas utility ($\sigma = 1$), equal utility weights ($\nu = 1$), equal weights on abilities in the government sector ($\alpha = \frac{1}{2}$), normalize A to unity and suppose that $\psi \equiv \psi_m = \psi_s = \psi_g = \psi_o > 0$ so that $G \equiv G_s = G_m = G_g = G_o$. Agent i receives wage offers $w_s^i = p_s G z_s^i$ in services, $w_m^i = G z_m^i$ in manufacturing and $w_g^i = w_g Ge$ in the government sector and will choose to work in the sector that pays most. This gives rise to two cutoff agents, $\bar{i}_m$ and $\bar{i}_s$ who are respectively indifferent between manufacturing and government sectors, so that $w^{\bar{i}_m} = w_g^{\bar{i}_m}$, as well as between service and government sectors, so that $w^{\bar{i}_s} = w_g^{\bar{i}_s}$. Suppose that government hires L_g workers. To do so it will have to offer a wage per effective unit of labor, w_g, high enough so that $L_g = \bar{i}_s - \bar{i}_m$. Using these relationships I can calculate these two cutoffs as a function of price and and the size of the government employment so that $\bar{i}_m(p_s, L_g) = \frac{1-\log p_s - L_g}{2}$ and $\bar{i}_s(p_s, L_g) = \frac{1-\log p_s + L_g}{2}$. I illustrate the problem of the worker in Figure 2(a) which plots the wage offers in each sector and the cutoffs, $\bar{i}_k(p_s, L_g)$ for $k = m, g$. Agents to the left of $\bar{i}_m(p_s, L_g)$ are relatively more skilled in manufacturing sector tasks and hence have higher wage offers than in services or government and hence choose to work in the manufacturing sector. Agents to the right of $\bar{i}_s(p_s, L_g)$ are relatively more skilled in service sector tasks and hence have higher wage offers and choose to work in services. Agents in between the cutoffs, will have a comparative advantage in government work and will hence choose to work in the government sector. Notice, that given the simple distribution of skills, output in the government sector is given by: $Y_g(L_g) = e^{\frac{1}{2}} L_g - \psi$. Thus government output is an increasing function of the level of government employment only.

The cutoff values are dependent on the price of service goods and the size of government employment. For the moment, suppose that government adjusts its wage offers to maintain a constant level of output, Ys_g, (and hence employment, L_g) and consider next the impact of a higher oil windfall. A windfall will influence the price of services and hence the distribution of workers across sectors. A windfall of revenue generates a greater demand for both types of consumption goods. To satiate the higher demand for non-traded service sector goods, more workers are needed in the service sector. New workers however will choose to work in services only if the service wages rise - which in turn can only happen if the service sector price increases. More formally, I can write output in each sector as a function of the respective cutoff (and hence the price): $Y_s(p_s; L_g) = G(Y_g(L_g))\left(e - e^{\bar{i}_s(p_s;L_g)}\right)$ and $Y_m(p_s; L_g) = G(Y_g(L_g))\left(e - e^{1-\bar{i}_m(p_s;L_g)}\right)$. Using these equations as well as the relationship between the two cutoffs and equation (21), I can determine the equilibrium price of non-manufacturing: $p_s = 1 + \frac{p_o O}{e}$. A higher windfall translates into a higher service sector price which results in an increase in service sector wage offers. In order for employment in government to remain unchanged despite the higher price, wages in the government sector must also rise. This results in a shift of workers from manufacturing to government and from government towards services resulting in a leftward shift of both cutoffs



(a) A workers decision - initial level of oil.

(b) A workers decision - an increase in oil, constant L_g.

(c) A change in the value of oil - an increase in oil, optimal L_g.

Figure 2: The mechanics of the model in a simple example.

to $\bar{i}^2_m(p^2_s; L^s_g)$ and $\bar{i}^2_g(p^2_s; L^s_g)$. As both cutoffs shift left, manufacturing productivity $(Y_m(\cdot)/\bar{i}_m = G(\cdot)(e - e^{1-\bar{i}_m})/\bar{i}_m)$ rises: that is $\frac{\partial Y_m(\cdot)/\bar{i}_m}{\partial i_m} < 0$. Intuitively, the workers who choose to remain in the manufacturing sector despite a higher price of non-manufacturing are the most able in manufacturing sector work. At the same time service sector productivity $(Y_s(\cdot)/(1 - \bar{i}_s) = G(\cdot)(e - e^{\bar{i}_s})/(1 - \bar{i}_s))$ falls: that is $\frac{\partial Y_s(\cdot)/(1-\bar{i}_s)}{\partial(1-i_s)} < 0$. Intuitively, new entrants into services pull down productivity since they are, on average, less skilled than those already employed in non-manufacturing. Finally, I can also show that non-manufacturing sector productivity, $Y_s/(1 - \bar{i}_s + L_g) = G(\cdot)(e - e^{\bar{i}_s})/(1 - \bar{i}_s + L_g)$ also falls as long as the government sector is not "too large".[18]

[18] In particular, the following inequality needs to be satisfied: $L_g < -2 - \log(e + p_o O) + 2\Omega(e(e + p_o O))$, where $\Omega(\cdot)$, where $\Omega(\cdot)$. To see this, notice that $Y_s/(1 - \bar{i}_s + L_g) = G(\cdot)(e - e^{\bar{i}_s})/(1 - \bar{i}_s + L_g) = G(\cdot)(e - e^{1-L_{nm}+L_g})/L_{nm}$, where $L_{nm} \equiv 1 - \bar{i}_s + L_g$. Then, $\frac{\partial Y_s(\cdot)/L_{nm}}{\partial L_{nm}} = \frac{eG(\cdot)\left((1+L_{nm})e^{L_g - L_{nm}} - 1)\right)}{L^2_{nm}}$. However, we know that $L_{nm} \equiv 1 - \bar{i}_s + L_g = 1 - \frac{1-\log p_s + L_g}{2} + L_g = \frac{1}{2}\left(L_g + \log(e + p_o O)\right)$. Substituting this into the

Government So far, I have taken the size of government employment as fixed. Suppose however that the fiscal authority takes the demand functions of agents (derived above in equations (20)) as given, cares equally about every agent so that $\gamma_i = 1$, and solves the Ramsey-type problem for the optimal wage, w_g^{opt}, in equation (22) and hence for the implicit optimal size of government, L_g^{opt}. Even in this simple case, without further simplification there is little I can say theoretically about optimal government wages and employment. As such, to gain some insight into the problem, for this simple example only, I approximate individual i's utility by a first order linear Taylor expansion in w_i around 1, so that $U(c_s^i(w_g), c_m^i(w_g)) = \log(\frac{(w_i+G(\cdot)p_oO-T)^2}{4p_s}) \approx 2(w_i+G(\cdot)p_oO-T-1)-\log(4p_s)$. Replacing individual utility by this approximation in equation (22), taking the first order condition from the resulting maximization problem, and applying the implicit function theorem to the resulting first order condition, it can be shown that the optimal government wage and the optimal employment of government increases with the size of the oil endowment: $\frac{\partial w_g^{opt}}{\partial poO} > 0$ and $\frac{\partial L_g^{opt}}{\partial poO} > 0$. Intuitively, higher oil endowment means a greater demand for both traded and non-traded goods. Demand for traded, manufacturing goods can be satiated by imports from abroad. Demand for non-traded goods however - which include government services - is satiated with locally produced goods, and hence through higher government wages results in a shift of labor towards the non-traded sectors of services and government. This is shown in Figure 2(c). The impact on manufacturing productivity is unambiguous - manufacturing productivity will increase both due to the smaller size of the manufacturing sector (and thus its more specialized nature) as well as due to the larger government sector which in turn increases each workers productivity. The impact on non-manufacturing productivity is mixed and will depend on specific parameters - but can potentially be negative.

5 Solving the Model

Distribution Function To calibrate and solve the model, I must pick a particular parametric form for the distribution of skills, $N(z_s, z_m)$, since the Roy model cannot be identified from cross-sectional wage data alone.[19] In what follows, I assume that skills are drawn independently from a normalized log-normal distribution with PDF:

$$n(z_s) = \frac{1}{z_s\theta\sqrt{2\pi}}e^{-\frac{(\log z_s)^2}{2\theta^2}} \text{ and } n(z_m) = \frac{1}{z_m\theta\sqrt{2\pi}}e^{-\frac{(\log z_m)^2}{2\theta^2}}, \tag{23}$$

derivative, I obtain: $\frac{\partial Y_s(\cdot)/L_{nm}}{\partial L_{nm}} = \frac{4eG(\cdot)(-1+\frac{e^{L_g/2}(2+L_g+\log(e+p_oO))}{2\sqrt{e+p_oO}})}{(L_g+\log(e+p_oO))^2}$. This term is negative if and only if L_g satisfies the initial inequality.

[19] This is because we observe only the outcomes of workers choices (in the form of a worker's observed wages) and not the talent draws (and hence the sectoral wage offers) that underpin these outcomes.

where, $\theta > 0$. The random talent draw, Z_i, has (geometric) standard deviation e^{θ}. The parameter θ thus governs the amount of variation in abilities and hence the observed productivity dispersion: lower values of θ imply more heterogeneity in ability and higher productivity dispersion.[20] Notice that I assume that θ is common to both manufacturing and service sectors and that talent draws are independent of each other. Whilst both these assumptions may seem restrictive, they allow me to derive simple, analytic solutions which provide insights into the workings of the model. In Kuralbayeva and Stefanski (2013) we had extend the (no-government version) of the model to allow correlated talent draws and different dispersions across sectors and we had shown that, quantitatively, these channels played only a limited role. Finally, notice that in Kuralbayeva and Stefanski (2013) and Stefanski (2015) Frechet distributions of talent were used. In this paper however, I choose to use log-normal distributions. Frechet distributions have the benefit of offering analytic solutions but I find that they predict too small a dispersion of wages in the government sector. In the presence of a government sector, a log-normal distribution, does far better in matching both private and public sectoral wages as I will show in the calibration section.

Employment Since z_s and z_m are independently drawn from log-normal distributions, the joint density function can be expressed as $n(z_s, z_m) = n(z_s)n(z_m)$. Using this, I can relate sectoral labor supply allocation to the parameter which controls the dispersion of skills across sectors.

First, start with government employment. In order to induce L_g workers to work in the government sector, the government will have to offer a wage, w_g, such that enough workers are drawn to that sector by earning more than they could in either manufacturing or non-manufacturing. Consequently, the chosen wage will be defined by the following:

$$L_g = P\left(w_g^i > w_m^i, w_g^i > w_s^i\right) = \int_0^{\infty} \int_{az_m^i}^{bz_m^i} n(z_s^i)n(z_m^i)dz_s^i dz_m^i, \tag{24}$$

where w_g^i, w_m^i and w_s^i are given by equations (13) and (14) above and $a \equiv \left(\frac{G_m(Y_g)}{G_g(Y_g)w_g}\right)^{\frac{1}{\alpha}}$ whilst $b \equiv \left(\frac{G_g(Y_g)w_g}{G_s(Y_g)p_s}\right)^{\frac{1}{1-\alpha}}$. Taking the level of government employment (and hence government wage) as given, the expected employment in services and manufacturing is:

$$L_s = P\left(w_s^i > w_m^i, w_s^i > w_g^i\right) = \int_0^{\infty} \int_{bz_m^i}^{\infty} n(z_s^i)n(z_m^i)dz_s^i dz_m^i \tag{25}$$

[20] The location and scale parameters of a log-normal distribution, i.e. μ (which in this case is zero) and θ, are more easily examined using geometric means and geometric standard deviations. The regular, arithmetic standard deviation, is given by $e^{\frac{1}{2}\theta^2}\sqrt{e^{\theta^2}-1}$ and is also increasing in θ.

$$L_m = P\left(w_m^i > w_s^i, w_m^i > w_g^i\right) = \int_0^{\infty}\int_0^{az_m^i} n(z_s^i)n(z_m^i)dz_s^i dz_m^i \tag{26}$$

Output Normalizing $A = 1$, the output of each private sector can be expressed as:

$$Y_s = G_s\int_0^{\infty}\int_{bz_m^i}^{\infty} z_s^i n(z_s^i)n(z_m^i)dz_s^i dz_m^i,\ Y_m = G_m\int_0^{\infty}\int_0^{az_m^i} z_m^i n(z_s^i)n(z_m^i)dz_s^i dz_m^i. \tag{27}$$

The output of the public sector can be given as:

$$Y_g = G_g\int_0^{\infty}\int_{az_m^i}^{bz_m^i} (z_s^i)^{\alpha}(z_m^i)^{1-\alpha} n(z_s^i)n(z_m^i)dz_s^i dz_m^i. \tag{28}$$

xxxx Here I need to show the above relationships. I think everything holds is relatively easy to show except $\frac{\partial Y_s/(L_s+L_g)}{\partial p_o O} < 0$. Just use the definition of Lg and the fact that Lg is constant.

For a fixed level of government employment, L_g, using the above equations for sectoral output and 21, it is easy to show that $\frac{\partial p_s}{\partial p_o O} > 0$. It then follows that oil endowments result in a reallocation of labor: $\frac{\partial L_s}{\partial p_o O} > 0$ and $\frac{\partial L_m}{\partial p_o O} < 0$. This shift in labor generates specialization (in manufacturing) and de-specialization (in services): $\frac{\partial Y_s/L_s}{\partial p_o O} < 0$ and $\frac{\partial Y_m/L_m}{\partial p_o O} > 0$. If - instead - I consider productivity in the non-manufacturing sector, I can also show that $\frac{\partial Y_s/(L_s+L_g)}{\partial p_o O} < 0$ as long as government employment is not 'too-large' i.e. if and only if $L_g < \frac{1}{\theta-1}\frac{L_s}{L_s+L_m}$. Later, in the calibration, it is easy to verify that this condition is satisfied for every country-date in our data-set.

6 Calibrating the Model

Estimating Skill Dispersion The parameter θ governs the dispersion of (unobserved) underlying skills. Consequently, this parameter will influence the distribution of wage offers in the manufacturing, service and government sectors. In particular, higher θ will tend to increase the dispersion of wage offers in all sectors and hence - since sectoral wage offers are either uncorrelated or positively correlated, this will tend to increase the implicit observed wages. As such, in order to match the parameter θ, I use a method of moments. In particular I calculate the standard deviation of a sample of log wages in a 'resource poor' country and match it to the implied standard deviation of log wages in the model. As in Kuralbayeva and Stefanski (2013) I obtain cross-sectional wage data from the 2009 US Current Population Survey (CPS) and find that the standard deviation of log wages in this sample is 0.58.[21] Then, using Monte-Carlo simulations, I calculate the corresponding standard deviation of the log-wage in the model and choose $\theta = 0.65$ so that the two match.

Government parameters To calibrate the government parameters, I first impose the restriction that $\psi \equiv \psi^s = \psi^m = \psi^o = \psi^g$ so that the impact of government on productivity is the same in manufacturing, service, oil and government sectors. The reason for this assumption is twofold: first, it simplifies the analysis and second there is no a priori reason to believe that the impact of government spending should affect productivity more in one sector than in another. I choose $\psi = 0.015$ so that the predicted *optimal* government employment in resource-poor countries in the model exactly matches government employment in the lowest decile of resource exporting countries in the data of approximately 17%.

This is a logical benchmark: I wish to reproduce the observed economic structure of resource-poor countries, and examine the impact of adding natural resources to those countries. Notice however, that if observed public sector employment in resource-poor countries were larger than optimal, then the above assumption will *underestimate* the extent of misallocation and government inefficiency in resource-rich countries. In other words, if resource-poor countries have inefficiently large government, then the scale of misallocation in resource-rich countries will be even larger than the model suggests. Of course, if resource-poor countries have governments that are 'too-small' relative to the optimum, since higher levels of public-sector employment in resource-rich countries could be seen as getting closer to the efficient levels of public sector employment, my measure of government inefficiency will *over-estimate* the extent of misallocation.

Of the two cases, it seems eminently more plausible that we are in the first and that we are underestimating the extent of misallocation in resource-rich countries. After all, resource-rich countries exhibit worse - rather than better - economic outcomes than resource-poor countries, so it would be surprising if it were resource-poor countries that were further away from the optimum. Furthermore, notice that public sector employment of 17% is a very reasonable choice. For example, in the US, government sector employment is approximately 13% of the labor force, whilst in the OECD it is approximately 19%. Our assumption that in resource-poor countries optimal government employment share is 17% is thus a half way point between these two extremes. Nonetheless, I demonstrate the robustness of this assumption on ψ in Appendix 12. Finally, I also impose that $\gamma_i = 1$ so that the government cares equally about all agents. I also examine this assumption in further detail in Appendix 12.

[21] Following Kuralbayeva and Stefanski (2013), Lagakos and Waugh (2012) and Heathcote et al. (2009) I include individuals aged 25 to 60 who have non-missing data on income and hours worked. Wages are before tax, and are taken to be the sum of wage, business and farm income. The sample is further restricted to include workers who average more than 35 hours a week of work and earn at least the Federal minimum wage.

The parameter α determines the importance of s sector versus m sector abilities in the government sector. Recall that α also determines the fraction of time that individuals spend working in one sector versus another. As such, this parameter also influences the average time spent by government workers working in s and m sectors. As such, I choose α to match the proportion of workers working in occupations that would otherwise (in the private sector) be classified as either m or s.

TO BE FINISHED

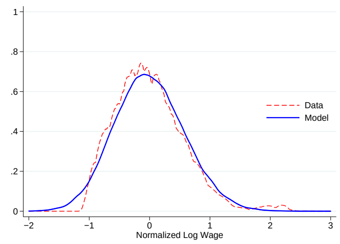
Preference parameters Finally, I follow Kuralbayeva and Stefanski (2013) in estimating preference parameters σ and ν. From, the household's problem I can derive an equation relating relative consumer expenditure on the relative price: $\frac{c_m}{c_s} = (\nu p_s)^{\sigma}$. Taking logs of this equation, I estimate elasticity of substitution between manufacturing and non-manufacturing goods using ICP data and find that $\sigma = 0.94$. Finally, I choose the preference parameter to be $\nu = 0.29$, to match the employment share in the manufacturing sector in resource-poor countries in the model to the employment share in manufacturing in the lowest decile of exporters in our sample (approximately 19%).

7 Results

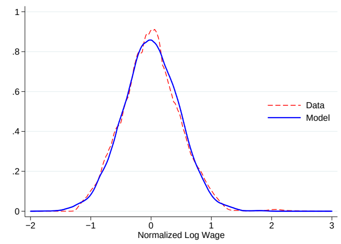
US Wage Distributions In our calibration, the key parameter choice is the dispersion parameter of the log-normal distribution, θ, chosen to match the standard deviation of observed log wages. Figure 3, shows the theoretical and empirical density of observed wages at the aggregate and sectoral level in the US data and the model. The log-normal distribution does well at matching the general dispersion of wages at the aggregate level. Furthermore, it does very well at matching the dispersion of wages in manufacturing and services as well as the government sector to which - importantly - it has not been calibrated. It's success in matching the dispersion of sectoral wages - especially government wages - speaks in support for the selection mechanism of the model. Importantly the matching of distribution of wages is the key distinguishing features of the more advanced model presented in this paper and the simple model presented in Stefanski (2015).

Natural Resource Results To examine the implications of the calibration I consider three different versions of the model: 1) A model without government; 2) a model where government employment is taken directly from the data and 3) a model where government employment is chosen optimally.

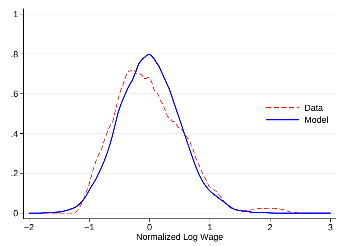
Table 4 compares the empirical windfall elasticites from the data (shown in Tables 2 and



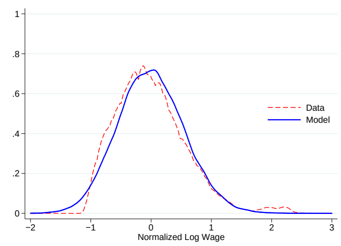
(a) Distribution of Wages (Log-Normal)



(b) Distribution of Wages in Government (Log-Normal)



(c) Distribution of Wages in manufacturing (Log-Normal)



(d) Distribution of Wages in Services (Log-Normal)

Figure 3: Distribution of wages in baseline model and the data, by sector.

3) with the corresponding windfall elasticities implied by the different versions of the model for sectoral employment, productivity and prices.[22] First, in column (1) and (1') of Table 4, I consider a version of the model without a government.[23] A doubling of natural resource windfalls in the optimal model results in a 0.8 percentage point decline in manufacturing employment, a 1.1% increase in manufacturing productivity, a 0.7% decline in non-manufacturing productivity and a 3.2% increase in the price of non-manufacturing goods. This basic model explains between 17% and 66% of the observed changes which is in line with the results of Kuralbayeva and Stefanski (2013).

In column (2) and (2') of Table 4, I now consider a case with government, where the observed government employment shares are fed directly into the model. Notice that the findings of Kuralbayeva and Stefanski (2013) continue to hold. The model captures all - and even slightly over-predicts - the elasticity of manufacturing employment. It also explains 76% of the elasticity

[22] In the data, we measure resource wealth as the ratio of current price exports of natural resources to current price GDP measured in international dollars. International dollar are constructed to have the same purchasing power over GDP as the U.S. dollar has in the United States. Since the US is a resource-poor country (according to this measure), we can view GDP in international dollars as the GDP of a country measured using a resource-poor country's prices. As such, in the model, we construct our resource wealth measure as the value of exports of natural resources divided by GDP, measured with the prices of a resource-poor country (i.e. one that has $p_O O = 0$).

[23] Thus, here the model is re-calibrated in that ψ is set to zero, and all other parameters are chosen to match the relevant moments described in the paper. In particular, I choose $\nu = 0.13$, $\theta = 0.65$ and $\sigma = 0.94$.

	Data	Model			Model/Data			Obs./Opt.
		(1) No Gov.	(2) Obs. Gov.	(3) Opt. Gov.	(1') No Gov.	(2') Obs. Gov.	(3') Opt. Gov.	
M. Emp., L_m	-0.014	-0.008	-0.020	-0.008	0.59	1.42	0.55	2.57
M. Prod, D_m	0.068	0.011	0.052	0.012	0.17	0.76	0.17	4.35
NM. Prod, D_s	-0.012	-0.007	-0.005	-0.005	0.55	0.41	0.41	1.01
NM. Price, p_s	0.048	0.032	0.111	0.029	0.66	2.31	0.61	3.75
G. Emp., L_g	0.017		0.017	0.006		1.00	0.38	2.64

Table 4: Changes in sectoral employment and sectoral productivity associated with resource wealth in the Data and Model.

in manufacturing productivity and 41% of the productivity in non-manufacturing productivity. Finally the model over-predicts the increase in non-manufacturing prices and - by construction - it accounts for all of the government employment elasticity.

Finally, in column (3) and (3') of Table 4, I show how the elasticities in the data compare to the model where government employment shares are chosen optimally. The model once more does relatively well and accounts for between 17% and 66% of the non-governmental employment and productivity. The interesting observation with regards to this version of the model however, comes when we compare the results of the optimal model to those of the model where observed government employment is fed directly into the model. The final column of Table 4 shows the ratio of implied elasticities in both these cases. Notice, from columns (2) and (3) that the optimal predicted government employment increases by only a fraction of the increase in government employment that is actually observed. In fact, from column (4), the observed increase in government employment is nearly three times larger than what it should be optimally according to the model. This implies that - on average - resource rich countries tend to employ 'too-many' people in the government sector creating a misallocation of resources. It turns out that this implicit misallocation has very large effects on various aspects of economies in resource rich countries.

Notice from column (4) of the above table, that inefficiently higher government employment acts to exacerbate the symptoms of Dutch Disease: the shrinking of manufacturing employment and the increase in non-manufacturing prices. Resource rich countries - on average - tend to have manufacturing sectors that shrink 2.57 times more and non-manufacturing prices that rise 3.75 times more than they would if efficient levels of government employment were chosen in those countries. This in turn has big effects on sectoral productivity. Higher prices, place greater pressure on the manufacturing sectors causing it to shrink which in turn imposes greater self-selection pressure in that sector. Very high prices mean that really only the most able workers in manufacturing remain in that sector, whilst all other workers shift to non-manufacturing (including government). As such, this contributes to productivity in non-manufacturing being lower than it would be with optimal levels of government employment.

The message from this exercise is that the specialization mechanism introduced in Kuralbayeva and Stefanski (2013) is strong enough to explain a big part of the large differences in sectoral employment shares and asymmetric productivity differences between resource-rich and resource-poor countries. Furthermore, the differences in the size of government employment between resource-rich and resource-poor countries act to magnify the differences in sectoral productivity, employment and prices produced by the specialization effect. Thus, the large size of government in resource-rich countries effectively amplifies the 'Dutch-Disease' effects of a smaller manufacturing sector and higher non-manufacturing prices. Finally, and most importantly, the observed government employment shares in resource-rich countries, tend to be significantly "too-large". I explore the impact of this latter effect on welfare and productivity in the following section.

8 The Resource Curse

The resource-curse - a well-known, stylized fact relating negative economic outcomes to resource windfalls. In the context of this paper, the mechanism for a resource curse is clear. If there is a misallocation of public sector employment in resource-rich countries - so that government employment is either too large or too small relative to the optimum - we will observe a lower productivity and welfare in the model. Table 5 shows the regressions of the ratio of observed-to-optimal aggregate productivity and welfare respectively emerging from the model, versus the size of natural resource windfalls (and the log of natural resource windfalls). From columns (1) and (2) observe that - in the data - a doubling of the natural resource windfall is associated with productivity that is 0.7% lower and a welfare that is 0.6% lower than it otherwise could be, if government employment were not mis-allocated. Equivalently, from columns (3) and (4), a one percentage point increase in resource export shares in GDP is associated with a productivity that is 0.17% lower than it otherwise could be and a welfare that is 0.13% lower than it otherwise could be. Notice, that these are big effects. Countries that have natural resource exports of 10% of GDP, will have productivity that is - on average - 1.7% lower and welfare that is 1.3% lower than it otherwise could be. Countries with 40% resource export share will have aggregate productivity that is - on average - a massive 6.8% lower and welfare that is 5.2% lower than it otherwise could be.

As I showed before, the misallocation occurs due to a government sector that tends to be too large in resource-rich countries. Importantly, I make absolutely no claims as to *why* the size of government employment tends to be what it is and in particular why government employment tends to be higher in resource-rich countries. Government employment in resource-rich countries

	(1) Rel. Prod. (D^{obs}/D^{opt})	(2) Rel. Welf. (U^{obs}/U^{opt})	(3) Rel. Prod. (D^{obs}/D^{opt})	(4) Rel. Welf. (U^{obs}/U^{opt})
log(NRE)	-0.007***	-0.006***		
	(0.002)	(0.002)		
NRE			-0.170***	-0.130***
			(0.036)	(0.035)
Obs.	340	340	340	340
R^2	0.086	0.073	0.099	0.077

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

Table 5: Regressions of the ratios of productivity and welfare in the observed and optimal models with respect to resource wealth.

can be non-optimal for a range of reasons (some associated with natural resources, and others not), but this paper takes no stand on the issue, and simply takes the observed size of government in resource-rich countries as given. As such, the observation that resource-rich countries have larger than optimal government is a characteristic of the given sample of data, and will not necessarily hold in every single resource-rich country. The findings here thus reflect the fact that in this particular sample of data, resource-rich countries tended to have public employment that was "too-large". It is - of course - entirely possible to find examples of resource-rich countries in the sample which the model predicts had "too-small" or "just-right" government. As two such specific examples, consider the cases of Chile and Canada in 2007. Chile's windfall measure was approximately 20% of GDP. This was associated with a productivity that was approximately 9% lower and a welfare that was approximately 8% lower than it otherwise could have been. This lower productivity and welfare, was a consequence of a government sector employment share that was - according to the above model - approximately 11.1 percentage points too *small* relative to predicted optimum. In the case of Canada, its windfall measure was approximately 11% of GDP in 2007. This was associated with a productivity that was only 0.1% lower and a welfare that was approximately 0.1% lower than it otherwise could have been. This was a consequence of the fact that Canada almost had 'the right' levels of government employment given its resource windfall.

The above fits in well with the institutional view of the resource curse. In particular by emphasizing the role of government misallocation, my theory lends support to arguments by Robinson et al. (2006), van der Ploeg (2010) and others that explanations of the resource curse should be sought outside economic structure perhaps - as they suggest - in areas such as political economy, weak institutions or property rights.

9 The Role of Weights

In the baseline model I focused on governments that weigh individuals equally within and across countries - so that $\gamma_i = 1$ in equation (22). Now I consider a government that can potentially weigh workers unequally and I allow these weights to vary across countries. In particular, I assume that governments values public sector workers differently from private sector workers according to this function:

$$\gamma_i = \begin{cases} m_g, & \text{if } i \in \Omega^g \\ 1, & i \notin \Omega^g \end{cases} \tag{29}$$

In the above m_g is the mass placed on public-sector relative to private-sector workers. I allow these weights to potentially vary across countries. In particular, I choose m_g to reconcile the discrepancies between optimal and observed government employment in resource-rich countries. Since the baseline model is chosen to match public sector employment in the lowest decile, for that particular decile m_g will be one and all other parameters will remain exactly as in the baseline. To match the observed public sector employment share of approximately 25% in the highest decile of resource-rich countries, I must set $m_g = 1.69$. Thus, in order for the model to optimally reproduce the higher observed public sector employment in the top decile of resource-rich countries, the governments in those countries must implicitly value public sector workers by 69% more than private sector workers. Thus, in principle, the model can optimally reproduce observed differences in public sector employment between resource-rich and resource-poor countries, but only if we assume a larger weight is placed by the social planner on government sector employees in resource-rich countries. Whilst there may be some justification to such a weighing scheme[24] , it nonetheless seems to be difficult to justify why governments in resource-rich countries should place more weight on the public sector than governments in resource-poor countries. This is an interesting and suggestive result, which can be seen as a complement to the discussion of the resource curse in the previous section. The higher weights on public sector workers can be interpreted as a measure of how much government workers in resource rich countries manage to bias government policy in their favor. Thus, this is further indication that there may be institutional failures in resource-rich countries that lead governments to effectively care more about their own employees than the employees of other sectors. Finally, since the model now exactly matches employment shares in the government sector, the sectoral and aggregate employment and productivity results are once more given by columns (2) and (2') of Table 4, although now - given the particular choice of weights - the observed government employment is optimal and there is no misallocation in the model.

[24] For example, in the model, government sector employees will be the lowest wage workers and hence placing greater weight on them can be seen as a form of progressive taxation.

10 Conclusion

Kuralbayeva and Stefanski (2013), show that - in the data - resource-rich regions have small and productive manufacturing sectors and large and unproductive non-manufacturing sectors and propose a mechanism that explains these productivity differences through a process of self-selection. Windfall revenues induce labor to move from the (traded) manufacturing sector to the (non-traded) non-manufacturing sector. A self-selection of workers takes place. Only those most skilled in manufacturing sector work remain in manufacturing. Workers that move to the non-manufacturing sector however, are less skilled at non-manufacturing sector work than those who were already employed there. Resource-induced structural transformation thus results in higher productivity in manufacturing and lower productivity in non-manufacturing.

In this paper, I show that in addition to the above facts, in the data, resource-rich countries also tend to employ a larger proportion of workers in the government sector than resource-poor countries. I then adapt the model of specialization of Kuralbayeva and Stefanski (2013) to include a productive government sector and proceed to examine optimal government employment in resource-rich countries. In particular, I show that the model can generate higher employment in the government sector when windfalls are higher. In a nutshell, government services are non-traded. Higher windfalls will increase demand for all goods and services - including government services - but since these cannot be imported, workers will shift to the government sector to satiate demand. Furthermore, even with a government sector, the specialization mechanism introduced in Kuralbayeva and Stefanski (2013) is strong enough to explain a large part of the asymmetric differences in sectoral employment shares and productivity between resource-rich and resource-poor countries. In addition, the differences in the size of government between resource-rich and resource-poor countries act to magnify the differences in sectoral productivity and employment shares produced by this specialization mechanism. Finally, the observed government employment shares in resource-rich countries, tend to be "too-large" relative to optimum. In the calibrated best-case-scenario model, government employment is nearly 10 times smaller than in the data. This implicit misallocation of resources has a large, negative impact on welfare and aggregate productivity. Using the calibrated model I find that a ten percentage point increase in resource windfalls is associated with a 1.70% percent lower aggregate productivity and a 1.30% lower welfare arising from government misallocation in resource-rich countries.

As such, the above theory and empirical evidence suggest that institutions may play a key role in driving the resource curse. In particular, this paper lends support to arguments by Robinson et al. (2006), van der Ploeg (2010) and others that explanations of the resource curse should be sought outside economic structure perhaps - as they suggest - in areas such as political economy, weak institutions or property rights which induce governments to be particularly large in resource-rich countries.

11 Data Appendix

Resource Wealth I follow Sachs and Warner (2001) and Kuralbayeva and Stefanski (2013) in defining natural resource "wealth" as the ratio of exports of natural resources (fuels, ores and metals) to GDP using WDI data. Following Kuralbayeva and Stefanski (2013) I use PPP GDP (in current prices) in the denominator of our measure since higher endowments of resources can potentially impact prices of non-resource goods (and hence measured GDP) influencing both the numerator and the denominator of our measure. Using PPP GDP, keeps prices fixed across countries and hence the measure only captures changing resource wealth. I have experimented with both measures or resource wealth, as well as other measures such as the ratio of *net* exports of natural resources to gross domestic product (both observed price and PPP). The results, however, are unaffected. For more detail of data construction see the Appendix of Kuralbayeva and Stefanski (2013).

Labor Shares To calculate the measure of productivity, I need to find expressions for labor shares, $1-\alpha_s$, for each sector s. Although these shares can potentially vary across countries, due to a lack of comprehensive cross-country sectoral data, I make use of OECD data to calculate the average annual share of employee compensation for each sector in OECD countries for the longest period of time that data is available. I calculate the labor share as the ratio of total compensation of employees (wages and salaries before taxes, as well as employer's social contributions) over sectoral value-added.[25] I find labor share in manufacturing is 0.57 whilst in non-manufacturing it is 0.53. For more detail of data construction see the Appendix of Kuralbayeva and Stefanski (2013).

Sectoral Employment I obtain sectoral employment data for 1980-2006 from the ILO KILM online database. To obtain the largest set of employment data, I combine ISIC revision 2 and ISIC revision 3 employment data. For more detail of data construction see the Appendix of Kuralbayeva and Stefanski (2013).

Prices Since I want to compare sectoral productivity across countries, it is crucial to control for any price differences that may exist between sectors across countries and over time. To do this I use the methodology and data from Kuralbayeva and Stefanski (2013). In particular in that paper we constructed country- and sector-specific price levels for each sector by combining the sectoral price levels from the World Bank's 2005 International Comparison Program (ICP) database and sectoral price indices from from the UN. The resulting series gives the price level

[25] Tables 7 and 8 in the the OECD Annual National Accounts, Volume 2, 1970-2008 (2009 prov)- Detailed aggregates, in millions of national currency

of a particular sector in each country relative to the price of the same sector in the US in 2005. For more detail of data construction see the Appendix of Kuralbayeva and Stefanski (2013).

Importantly, as is mentioned in Kuralbayeva and Stefanski (2013), although the ICP study is especially built to provide accurate cross-country measures of price differences:

> it does have some well known limitations. The main objection is that expenditures are valued at the actual transaction prices paid by purchasers and hence may include delivery charges and any taxes payable (or subsidies received) on purchased products. This may be an issue if taxes/subsidies vary systematically with resource wealth. We recognize this fact, but our hands are tied for lack of better data. In the main body of the paper, we use a simple version of our model to show that to account for observed productivity differences, unrealistically large subsidies would be necessary. Notice also that this re-basing is not driving our results and we see similar productivity differences when value-added is left in constant US dollars.

Aggregate Capital I follow Caselli (2005) and Kuralbayeva and Stefanski (2013) and use the Penn World Tables (version 6.3) to construct estimates of aggregate capital stock. This is done using the perpetual inventory method with the depreciation rate set to 0.06. For more detail of data construction see the Appendix of Kuralbayeva and Stefanski (2013).

Sectoral Capital I follow Caselli (2005) and Kuralbayeva and Stefanski (2013) in estimating sectoral capital. First, assume that economies consist of five sectors: agriculture (A), mining and utilities (MU), manufacturing (M), construction (C) and services (S). Then, assume that the production function of each sector, s, is of the form given in equation 2. If I also assume that the rates of return on capital are equalized across sectors (an arbitrage condition), then it is easy to show that the above functional form implies that for any two sectors s and s', the following holds:

$$\alpha_s \frac{P_s^D Y_s}{K_s} = \alpha_{s'} \frac{P_{s'}^D Y_{s'}}{K_{s'}}, \tag{30}$$

where P_s^D is the domestic producer price of sector s goods. For more detail of data construction see the Appendix of Kuralbayeva and Stefanski (2013).

Aggregate Human Capital I follow Kuralbayeva and Stefanski (2013), Caselli (2005) and Hall and Jones (1999) in constructing a measure of aggregate human capital from the Barro and Lee (2010) average years of schooling data set. For more detail of data construction see the Appendix of Kuralbayeva and Stefanski (2013).

Sectoral Human Capital To calculate sectoral human capital, I follow Kuralbayeva and Stefanski (2013) and Caselli (2005) when estimating sectoral human capital. I assume that the ratio of human capital between any two sectors is constant across countries and time and equal to the corresponding ratio in the US and that labor shares in the last two measures of productivity, $1-\alpha_s$, are identical across countries, constant over time and equal to OECD averages. For more detail of data construction see the Appendix of Kuralbayeva and Stefanski (2013).

Public Sector Employment Public sector employment data is from the ILO which "covers all employment of (the) general government sector as defined in System of National Accounts 1993 plus employment of publicly owned enterprises and companies, resident and operating at central, state (or regional) and local levels of government. It covers all persons employed directly by those institutions, without regard for the particular type of employment contract." A limited subset of the public employment data is provided at the ISIC one sector level and in that (very limited) subset, public employment is overwhelmingly in the non-manufacturing sector. As such in the baseline experiment of this paper - in order to maintain as large a sample of data as possible - I shall assume that all government employment belongs entirely to the non-manufacturing sector.

Summary Statistics Table 6, presents summary statistics for the main economic variables: (ISIC) sectoral employment shares, public or government sector employment share, sectoral sectoral TFP (physical and human capital), value-added per worker (this is the sum of all sectoral value-added data divided by the total labor force), GDP/capita in international 2005 dollars from the WDI and the natural resource export share.

Variable	Sector	N	mean	sd	min	max	p10	p90
Emp. Share	A	340	0.10	0.10	0.01	0.67	0.02	0.21
	C	340	0.08	0.02	0.03	0.14	0.06	0.10
	S	340	0.18	0.04	0.07	0.30	0.12	0.24
	M	340	0.65	0.10	0.22	0.82	0.51	0.76
Emp. Share	G	340	0.21	0.08	0.06	0.54	0.11	0.34
TFP	A	340	2.80	0.81	0.99	5.23	1.70	3.84
	C	340	216.95	54.41	98.75	417.48	143.08	280.86
	S	340	128.14	21.09	72.99	234.69	106.34	147.25
	M	340	139.17	54.24	26.84	382.27	74.90	193.26
	ACS	340	106.96	19.51	49.37	204.96	90.29	126.21
	ACSM	340	111.75	22.29	50.10	223.95	86.90	134.65
VA/worker	-	340	50553	21644	6038	170198	18150	71069
gdp/capita	-	340	23279	11281	2489	72783	8586	35164
NR	-	340	0.04	0.06	0.00	0.39	0.01	0.08

Table 6: Summary statistics for data.

	(1)	(2)	(3)	(4)	(5)
		Model/Data			
	Opt. Gov.	Opt. Gov.	Opt. Gov.	Opt. Gov.	Opt. Gov.
$\psi =$	***0.015***	*0.008*	*0.020*	*0.038*	*0.079*
M. Emp.	**0.53**	0.55	0.52	0.50	0.46
M. Prod	**0.36**	0.35	0.37	0.39	0.43
NM. Prod	**0.36**	0.40	0.34	0.29	0.22
NM. Price	**0.63**	0.61	0.63	0.66	0.71
G. Emp.	**0.12**	0.09	0.13	0.17	0.22
Imp. Opt. Govt. Emp.:	**0.17**	0.13	0.19	0.25	0.33

Table 7: Changes in sectoral employment and sectoral productivity associated with resource wealth in the Data and Model under different assumptions on ψ.

12 Robustness and Extensions Appendix

Optimality in resource-poor countries NEEDS TO BE COMPLETED/UPDATED

In this section I carry out a robustness exercise on the parameter ψ which influences the optimal size of government. Column (1) of Table 7 reproduces column (3') of Table 4 and shows the percentage of sectoral productivity and employment explained by the baseline version of the model under the assumption of optimal government size. The top row of the table presents the value of ψ in the current calibration whilst the bottom row shows the observed 17% government employment share in the lowest decile of resource-poor countries that the parameter was chosen to reproduce. Notice that in the baseline version of the model only 12% of the increase in government employment share between resource-rich and resource-poor countries is captured by the model. As mentioned above, it is however eminently likely that most countries - including resource-poor countries - have some form of inefficiencies that translate into government sectors that are too large. In column (2), I set $\psi = 0.008$ so that the true optimal share of government employment is a lower 13% - like that in the US. In this case the model only explains 9% of the increase in government employment share. Notice however from columns (3)-(5) of Table 7, that choosing a larger ψ to match government employment shares in the OECD (19%), the EU (25%) or Sweden (33%), does indeed result in the model predicting slightly larger increases in government employment in resource-rich countries. Notice however, that these increases are still significantly smaller than observed in the data and that the different choice of ψ implies the model completely misses the level of government employment found in resource-poor countries.

13 Theoretical Appendix

Propostion 1. *Assuming that employment in each sector is positive, then $a \leq c \leq b$.*

Proof. First, notice that $a < b$, since if it were not then from equation 24, employment in government would be zero contrary to the assumption that each sector's employment is positive. Then, I proceed by contradiction. First, suppose that $a < b \leq c$. Since $b \leq c$, substituting for b and c, I obtain: $\frac{G_g(Y_g)w_g}{(G_m(Y_g))^{1-\alpha}} \leq (G_s(Y_g))^{\alpha}p_s^{\alpha}$. However, I also know that $a < c$. Substituting for a and c, I obtain: $(G_s(Y_g))^{\alpha}p_s^{\alpha} < \frac{G_g(Y_g)w_g}{(G_m(Y_g))^{1-\alpha}}$. Putting these together implies that: $\frac{G_g(Y_g)w_g}{(G_m(Y_g))^{1-\alpha}} < \frac{G_g(Y_g)w_g}{(G_m(Y_g))^{1-\alpha}}$, which is a contradiction. Second, in a similar fashion, I can show that supposing $c \leq a < b$ also leads to a contradiction. This then implies that, $a \leq c \leq b$. □

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