Taxes, Natural Resource Endowment, and the Supply of Labor: New Evidence

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Abstract

Using the work-leisure choice model, we compute equilibrium hours-worked for a number of Arab countries because labor supply data are unavailable, which rendered policy-making difficult. We compute hours-worked for the G7, and show that the model fits the data well. We use this evidence as a yardstick to evaluate the model for the Arab countries. With the effective marginal tax rate close to zero in the oil producing countries, hours-worked increase significantly. We show that natural resource endowment is a requisite predicting factor for the model in this case. It appears that natural resource capital acts exactly as a tax. In other words, it increases the wedge between real wages and marginal productivity, hence, *natural resource wedge*. The higher the natural resource endowment, the less hours people worked. Most importantly, we provide wider support to the model and confirm that the labor supply is elastic in all Arab countries. This finding confirms previous research that workers respond to incentives, which has serious implications for tax and social security policies. We also provide some policy simulations pertinent to poverty and welfare.

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1. Introduction

Our primary objective is to provide information about the labor market such as hours-worked, the Frisch elasticity of labor supply, and labor productivity in a number of Arab countries. We do that because such data do not exist. Without such data the discussions about labor, fiscal, social security, welfare and poverty policies, among others, would be misguided. We focus on the macroeconomic implications of some policy issues.

To compute hours-worked, we calibrate a theoretical model, namely, the work-leisure choice model, which Nickell (2003), Prescott (2004) and Shimer (2009) demonstrated its goodness of fit to G7 data.[i] It s a simple and informative model, where the Arabic data of the main predicting factors are available, albeit in dubious quality.

The main challenges are that data on hours-worked for the Arab countries are not available, which makes assessment of the goodness of fit of the model difficult. Additionally some of the Arab countries, namely the Gulf Cooperation Council countries (GCC), are oil and gas producers with almost tax-free economies. With the effective marginal tax rate close to zero, the model predicts a very high, nonsensical labor supply.

To deal with these challenges we fit the model to the G7 data and use that as a yardstick to assess the goodness of fit of the model to the Arab countries. For the group of the oil-producing countries, we introduce natural resource endowment into the model. It turned out that natural resources create a wedge between real wages and the marginal product of labor similar to the *tax* or *labor wedge*. The increase in the share of natural resource reduces hours-worked. It discourages work and reduces labor supply.

Our results confirm Noland and Pack (2007) who argue that Arab oil-producing countries are characterized by the generation of large oil rents and boom and bust cycles driven by the world price of their export. They show that the shares of rent in government revenues and in GDP are relatively high.

These shares are between 70 to 85 percent of government revenues, and between 25 to 36 percent of GDP. They conclude that “fewer individuals are involved in the production of wealth, and the majority of them are involved in its distribution and consumption.”

We make a number of contributions. First we compute equilibrium hours-worked for five Arab non-oil producers (Egypt, Jordan, Morocco, Syria, and Tunisia) and for seven oil-producers: Algeria plus the GCC (Bahrain, Kuwait, Oman, Qatar, the United Arab Emirates (UAE) and the Kingdom of Saudi Arabia (KSA)), for which data do not exist. This allows us to compute and analyze the Frisch elasticity of the labor supply, which plays a major role in policy design. Also, this allows us to shed light on productivity in the Arab countries relative to the G7.

Second, we are unaware of any published articles on the work-leisure model with a natural resource endowment. We modify the model and show that such endowment works just like a tax on labor supply.

Third, we confirm the validity of the work-leisure, intertemporal-intratemporal substitution model using data from the Arab countries. A theory is valid if it fits different data at different times and places. So far, the bulk of the evidence for the work-leisure model relies on data from developed countries. We show that Arab countries' labor supply curves are just like the G7 (also elastic), which has important policy implications.[ii] Non oil-producing Arab countries work long hours, but their relative productivities are low, thus they are relatively poorer. Oil-producing countries work much less.

Finally, we solve the model stochastically and produce baseline projections of future labor supply for the Arab countries. Then we conduct policy scenarios. For the GCC countries we ask how much welfare will change if the GCC countries embark on a diversification policy, which reduces the reliance on oil as the main source of income. We find very significant increases in the lifetime consumption equivalent. Second, we ask how much welfare will change as a result of the introduction of a permanent consumption tax.

Finally, we ask how long it will take to eliminate poverty if a policy to reduce the tax rate on household is adopted in non oil-producing countries. We find that a small, permanent tax cut can reduce poverty by more than half in approximately 12 years.

The model is presented next. In section 3 we produce and discuss the results. Section 4 includes policy simulations. Section 5 is a conclusion.

2. The Model

We begin with the model found in Prescott (2004) to derive the labor supply.[iii] A similar model is presented in Nickell (2003) and Shimer (2009). Then we modify the model to include natural resource endowment.

The utility function of a *stand in household* who faces a work-leisure decision is give by:

$$1 \quad U = E\left\{\sum_{t=0}^{\infty}\beta^t[\log c_t + \alpha\log(100-h_t)]\right\}$$

The utility function depends on the expected discounted sum of consumption c and leisure, where 100 is the number of hours available for individuals to work in a week and h is hours worked in “market activities”. The expectations operator E does not necessarily mean rational expectations, and $0 < \beta < 1$ is the discount factor and specifies the degree of patience. A high value means more patience for consumption and leisure. The parameter α is > 0 and denotes the value of the non-market productive time per household. It could be the relative value of the time spent working at home. Typically, it is the relative value of leisure. The production using this time is untaxed. The utility function includes one consumption good as in Christaino and Eichenbaum (1992); We find no contradiction of such an assumption with reality in the Arab countries.

The stock of capital evolves according to:

2 $k_{t+1} = (1-\delta)k_t + x_t$,

where k is the stock of capital and x_t is gross investments. The depreciation rate is δ.

There is a *stand-in firm* with a Cobb-Douglas constant returns to scale technology of production:

3 $y_t = A_t k_t^{\theta} h_t^{1-\theta} \geq c_t + x_t + g_t$, where g is government expenditure.

Total factor productivity is *exogenous* and is given by A_t.[iv] The parameter $0 < \theta < 1$ is the share of capital.

It is argued that the technical progress is exogenous because it plays no role in the inference being drawn.

The household's date t budget constraint is:

4 $(1+\tau_c)c_t + (1+\tau_x)x_t = (1-\tau_h)w_t.h_t + (1-\tau_K)(r_t - \delta)k_t + \delta k_t + T_t$,

where w is the real wage, r is the real interest rate or rental capital, and T is transfer payment. The tax rates of consumption, investments, labor, and capital are given by τ with the subscripts c , x , h , k denoting consumption, investments and capital, respectively.[v]

Prescott (2004) derives the tax rate in the model theoretically (see appendix 2 for details). He derives an aggregate effective marginal tax rate on labor income using both the tax rate on consumption τ_c and on labor τ_h. It is the fraction of additional labor income that is taken in the form of taxes, holding investments fixed.

5 $$\tau = \frac{\tau_h + \tau_C}{1 + \tau_C}$$

It is also important to note that the marginal and the average labor income taxes are very different. All tax revenues, except for that used to finance the pure public consumption, is given back to households as lump-sum transfer payments (independent of the household's income). Note that the model economy's consumption in the utility function above is $c = C + G - G_{mil} - IT_c$, where G is public consumption and G_{mil} is military spending. And the model economy's output in the production function is $y = GDP - IT$.

In the Arab countries, public consumption is large, and so is the subsidy. In some Arab countries, only total amount of subsidy is reported, which is the sum of production and consumption goods subsidy. We were forced to make an assumption on splitting them. The data appendix includes more information on our assumptions.

From the above we get the FOC, then the marginal rate of substitution equal to the price ratios:[vi]

6 $$\frac{\alpha/(1-h_t)}{1/c_t} = (1-\tau)w_t$$

And from the production function, the marginal product of labor is equal to the real wage rate:

7 $$w_t = (1-\theta)k_t^{\theta}h_t^{-\theta} = (1-\theta)y_t / h_t$$

The equilibrium labor supply is solved for from the two FOC above,

$$8 \quad h_{it} = \frac{1-\theta}{(1-\theta) + \frac{c_{it}}{y_{it}} \frac{\alpha}{1-\tau_{it}}}$$

The equation above is calibrated for a number of countries i over t time periods. The parameters which do not have subscripts will be calculated as the *average* across the countries in the sample, and fixed throughout unless stated otherwise. For example, every country will have a fixed value of θ in equation 8 equal to the average of θ across the countries. The intertemporal substitution is captured by the ratio of consumption to GDP in equation 8. The intratemporal substitution is captured by the tax rate in equation 8. If the effective tax rate on labor income is expected to be lower in the future, for example, people will increase their current consumption.

2.1 introducing natural resource endowment effect

For the GCC countries and Algeria, the theory predicts that a low tax rate τ increases hours worked. If we fit the model for the GCC, hours worked will be very high, greater than for the US and Japan. To ameliorate this problem we modify the model by introducing oil endowment.

The production function becomes:

$$9 \quad y_t = A_t N_t^{\omega} k_t^{\theta} h_t^{1-\omega-\theta},$$

where N_t could be the natural resource utilization rate, R_t. Stiglitz (1974) focuses on the ratio of resource utilization to the stock of natural resources, i.e., $\gamma = R/S$, while Solow and Wan (1976) only use the flow. In any case it is immaterial for our case whether we have R_t or γS in the production function because the share parameter ω is what enters in the equilibrium solution of the hours-worked. The budget constraint in equation (4) will include income per capita from natural resources on the RHS.[vii]

Solving the model the same way gives:

$$h_{it}^{N} = \frac{1-\omega-\theta}{(1-\omega-\theta)+\frac{c_{it}}{y_{it}}\frac{\alpha}{1-\tau_{it}}}, \quad (10)$$

where the superscript N refers to natural resources. The share of hydrocarbon in output is ω. For ω >0 this formula predicts that $h^N < h$ in equation (8). For ω =1, h^N <0 and for ω =0, h^N is identical to h. For $h_{it}^N \geq 0$, $\omega^{\max}$ must be equal to $1-\theta$.

3. Calibration

The data are fully described in the appendix. Note that our data are measured in PPP term, rendering them larger in magnitude than the actual reported data. The reported/measured data for the Arab countries have dubious quality, due to, for example, missing data points. We use averages over the period 1999 to 2006 to calibrate the model, but for some countries the averages are for less than the full sample. Consumption data are also dubious. These are residuals of the equation of exchange or the income identity.

Table 1 includes our estimates of hours-worked for the G7 for the period 2000 to 2008. The fit of the G7 is our yardstick for the goodness of fit of the model for the Arab countries because Arab countries do not report hours-worked.

The countries are listed in the first column. Actual hours-worked data are reported in the second column. Because α is unknown we could choose α that gives us the perfect fit, where the estimated value is equal to the actual. For that reason we will fix the value of α, the relative value of leisure, to the average of the G7. For our sample α is 1.78. We also took the average share of capital θ to be 0.38. With these two parameters set equal to the averages of the G7, we could compare the effect of taxes on the G7 countries hours-worked.

We computed the share of capital from National Income Accounts, as gross operating surplus / GDP ratio. The predicted hours-worked are reported in the third column. The fourth column reports the difference between the actual and the estimated values. The model fits Canada, Italy, and Japan best; slightly over-predicting in the case of Canada, and slightly under-predicting in the cases of Italy and Japan. On average, however, the fit is fine with a difference of 0.06. The G7 average weekly hours-worked per person is about 23.

The fit can be made tighter when we allow α to vary across countries. We report the same value for α in table 1. Allowing α to vary across the G7 countries shows that for Italy the model has a value of α right on the average of 1.78. Three countries Canada, UK, and the US have a value of α equal 1.6, which is below the G7 average. The non-English speaking countries France, Germany, and Japan have a value of α higher than 2. The relative value of leisure is much higher in the non-English speaking G7 countries.

Now we can turn to estimating hours-worked for the Arab non-oil producing and labor-abundant countries. Note that the labor force in the GCC countries is dominated by imported labor, and the absolute majority of citizens work in the government. We do not make any distinction between imported and domestic workers.

We compute the tax rate as we did for the G7, as explained in the appendix. Note that there are no time series data for the marginal tax rates for Arab countries. We also conduct a sensitivity analysis.

We have information about the shares of labor and capital from the national income account for each country, but we only need one of the shares to calibrate the equation. We calculate the share of capital as gross operating surplus to GDP and the share of labor as compensations to employees to GDP. We compute the averages of the Arab countries and fix the share of capital, θ to the average at 0.48. And we try α of 1.78, which is the same as average G7 value. Fixing θ and α isolates the effect of taxes on the supply of labor.[viii]

We have no actual data for the Arab countries, but the prediction of the model seems sensible relative to the G7. The average weekly hours-worked per person is 19.87, which is lower from the G7 average of 23.4. Beginning with the most obvious, the Syrians work much more than all other countries (26.1hours) because they have the lowest tax rate among Arabs and their c/y ratio is less than average G7. Egypt's estimate of hours-worked is less than Jordan's despite the Jordanians having a higher tax rate. This is because the consumption-output ratios are quite different. The Egyptians' c/y ratio is 0.98 while that of Jordan is 0.79. Egypt's c/y ratio significantly exceeds the G7 average. All Arab non oil-producing countries have a high consumption to output ratio, far exceeding the developed countries in PPP terms. The North African nations, Tunisia and Morocco, work less than the Syrians and the Jordanians because they pay relatively higher taxes. Both Morocco and Tunisia have an average weekly hours-worked of approximately 17.

The results in table 1 confirm the literature's findings that when people are taxed the same rate they, they most probably supply the same amount of labor. Taxes affect labor supply decisions in the Arab countries.

Our estimates of the Frisch elasticity in table 1 suggest that the labor supply curves for the Arab countries are elastic, particularly in Egypt, Morocco and Tunisia; supporting the literature. Fairly elastic labor supplies spares countries the trouble of facing the choice of either increasing taxes on the young, thereby reducing their welfare, or not honoring the promise made to the old to avoid making them worse off. One thing large labor supply elasticity means is that as the population ages, promises of payment to the current and future old people cannot be financed by increasing taxes.

Our estimates of the labor supply can explain why the non-oil producing Arab countries have low productivity. There should be no problem with working fewer hours if efficiency and productivity are high. However, this is not the case for the Arab countries. Table 2 reports the decomposition of income per working age population relative to the average G7. GDP per working age population is decomposed to GDP per hour and hours per working age population, i.e., labor productivity multiplied by labor utilization. The Arabs do not seem to have many problems with labor utilization. They work long hours, but their relative productivity level is significantly low. The Arabs work hard, produce relatively less output per hour, and they are poorer than the G7. Any increase in the tax rate in the Arab non-oil producing countries will make them even poorer.

Now we turn to the oil-rich and labor-scarce Arab countries. These include the GCC countries plus Algeria. The GCC effective marginal tax rate is very low, about 5 per cent (social security tax, but no income nor consumption taxes) compared to Algeria, which is 34 per cent. We estimate hours-worked over two samples. The first sample is when the price of oil was low; hence oil revenues to GDP were low. The second sample is when the price of oil was high; hence the revenues to GDP were high. The theory predicts that households will increase their supply of labor in periods of low oil revenues and low rent.

The share of hydrocarbon in GDP ω is taken from the budgets. It is basically the ratio of oil and gas revenues to GDP $p^o q^o / (p^o q^o + p^{no} q^{no})$ where the superscript o denotes hydrocarbon (oil and gas), hence p^o is the price of the hydrocarbons and q^o is the quantity. The superscript no denotes the non-hydrocarbon revenue (?).

Results of the estimates of the GCC and Algeria are shown in table 3. For sensitivity analysis, we use values of α 1.3, 1.5, and 2.0. The average predicted equilibrium weekly hours-worked in the GCC is between a high of approximately 20 hours and a low of 13, during the sample when oil revenues as a share of GDP were low. This is a sensible range compared with previous estimates of the G7, and Arab non-oil producing countries. This average is lower than the average of the non-oil producing Arab countries. Algerians work slightly longer hours than the average GCC, but less than Bahrain. Bahrain, Oman, and the UAE predicted weekly hours-worked exceed the average GCC. They also work harder than the average Arabs. The citizens have higher labor participation rates and greater involvement in the labor market than other GCC countries. Bahrain and Oman in particular implement active labor market policies to reduce unemployment and to encourage their citizens to work. Kuwait, Qatar, and Saudi Arabia work relatively fewer hours than all other Arab countries, whether oil or non-oil producing. These three countries are major oil and gas producers.

In the second sample over the period of high hydrocarbon revenues, hours-worked plummet just like the theory predicts. The average falls somewhere between 5 and 7 hours. Algeria's hours fall between 5 and 7 hours. Among the GCC, Oman's hours-worked decline is the largest, between 8 and 12 hours. On average, GCC hours-worked could decline to nearly 8 hours due to higher hydrocarbon revenues. This says a lot about the extent of the rent in these economies and reflects the manifestation of the oil curse in the labor market.

We solve the model for the effective marginal tax rate τ for the G7 and for ω in the GCC, i.e., the *resource wedge*. Figure 1 plots the *labor wedge* for the G7 and the *resource wedge* for the GCC. The averages over the sample 1991-2006 are 0.41 and 0.36 for the GCC and the G7, respectively. The natural resource wedge works the same way the labor wedge: it increases the wedge between real wages and the marginal product of labor.

To confirm that the estimates of labor supply are highly sensitive to the tax rate, we report estimates with different tax rates. In Prescott (2004) the marginal tax rate $\tau_h = t_{ss} + 1.6\bar{\tau}_{inc}$, where τ_{ss} is social security tax and τ_{inc} is the marginal income tax. The number 1.6 reflects the fact that the marginal income tax rates are higher than the average tax rates, and the number delivers a marginal income tax found in Feenberg and Coutts (1993) for the U.S.. Their calculation of the marginal income tax is based on a representative sample of tax records. They calculate how much the tax revenue increases if every household labor income is increased by one percent. The total change in tax receipts divided by the total change in labor income is their estimate of the marginal income tax. We play with this number, and recalibrate hours for values of 1.0, 1.6, 2.6, and 3.6. We prefer the central estimates because we believe the estimates are neither very low nor very high. It is inconceivable that the tax rates are above 40 percent in the Arab countries (see appendix 2).

Our paper does not include the effect of the population dynamics. Demographics play major role in the study of labor supply. Noland and Pack (2007) provided demographic statistics for the Arab countries, and show that (1) population growth is slowing down; (2) fertility rates are falling; (3) median population age is projected to rise; (4) female labor force participation is trending up and projected to reach 60 percent in many Arab countries by 2020. The supply of labor will probably increase in the future.

4. Policy simulations

Diversification, consumption tax, and welfare in GCC

We provide a baseline, stochastic projection for hours-worked until 2050. Then we simulate policy scenarios. The first policy scenario is about the welfare effect of taxes. We study the effect of a reduction in the share of oil in GDP in the GCC as a result of a policy that aims at diversifying income.

We examine the effect of a permanent reduction in the share of hydrocarbon in GDP, ω by an amount equal to 0.25 standard deviations. We assume that the GCC countries have successfully managed to diversify their economies away from hydrocarbon by the year 2020, hence a permanent reduction in the share of oil and gas in GDP from the year 2021 to 2050 (the end of our simulation). The share of oil and gas revenues, as we stated earlier, is $\omega = p^o q^o / (p^o q^o + p^{no} q^{no})$. Diversification means a reduction in the value of ω coming through an increase in $p^{no} q^{no}$ (the non-hydrocarbon output), thus higher share of labor in the production function and a lower share of natural resources. The increase in labor supply increases output and consumption.

The welfare effect of the policy is measured by the *lifetime consumption equivalent,* which is the change in real consumption required to make the households indifferent to the policy.

We solve the model numerically over the period 2004 to 2050 using stochastic simulation with 10000 iterations.[ix] The parameters $\alpha = 2$ and $\theta = 0.51$ are the average values of GCC over the sample 1991-2003. The parameter ω is assumed to be a random walk process over the forecasting period; the error term has a mean of zero and a standard deviation equal to the sample value. To simplify the solution of the model further we appeal to the stochastic implications of the lifecycle-permanent income theory of consumption and assume that the conditional expectations of the future marginal utility of consumption follow a random walk (Hall, 1978). Working age population grows at historical trend. The capital stock's starting value is assumed to be twice the size of real GDP in 1960. The depreciation rate was assumed to be 0.05. The value of the exogenous technical change A in the production function is the constant term, and was calibrated such that the value of output in 2004 was not far away from 2003 in order to ensure we have a sensible projection.

Baseline level of consumption is estimated to be increasing in all GCC countries, but leveling off in the far future. The consumption to output ratio projection depends on the projected level of output from the production function. In the baseline solution, Bahrain's ratio has a negative trend suggesting that output is projected to increase by more than consumption. This ratio rises in Kuwait, Oman, and Saudi Arabia. The most significant positive trend is in Saudi Arabia. The ratio is constant in the UAE.

The second policy simulation introduces a 5 percent permanent value added tax (consumption tax τ_c in the GCC on welfare, which translates to a 9.5% increase in the tax rate τ (equation 5)).

The results of the two policy simulations are reported in table 4, which has 14 columns with countries in the first column. We report the averages of the share of hydrocarbon in GDP ω; the standard deviation of ω; and the consumption to GDP ratio over the sample from 1991 to 2003. In the second panel, columns 5, 6, and 7 report the average projected hours-worked, the value of the share of hydrocarbon, and the c/y ratio. In the third panel, columns 8, 9, 10, and 11 we report the results of the first policy, policy I. In column 11 we quantify the policy of a $0.25\sigma_\omega$ reduction, in US dollars. And in the last three columns we report the results of the second policy. Note the jump in the labor supply under policy I. The reduction in the hydrocarbon revenues is very small because we intended to show the welfare impact of a small change in policy. The reduction is 0.1 on average and about 1.4 billion US dollars. This reduction in hydrocarbon revenues is matched by an equal reduction in government spending to keep the budget constraint unchanged. We assume that the government can reshuffle the budget in any way it chooses.[x]

Table 5 reports the lifetime consumption equivalent of the two policies. Clearly, the welfare improvement, resulting from the diversification policy and measured in lifetime consumption equivalent, is positive and sizable. In the case of Oman it is 14 per cent, followed by Qatar (10.8 per cent), and Kuwait (9.3 percent). The Kingdom of Saudi Arabia has the lowest and a relatively better diversified economy than other GCC countries. The share of manufacturing and agriculture in GDP are reasonably high. The World Bank Development Statistics reports Saudi Arabia's agriculture, manufacturing, and services value added in the total GDP in 2008 to be 2.3, 8 and 27.2 percent, respectively.

Bahrain is the smallest oil-producer; its main source of income is not oil. Its welfare improvement from the diversification policy is equal to that of Saudi Arabia. In the UAE, the welfare improvement measured by lifetime consumption equivalent is 5 per cent, the third lowest. The share of agriculture, manufacturing, and services value added in 2006 reported by the World Bank Development Statistics are 2, 12.25 and 39.11 percent, respectively. Qatar, Kuwait, and Oman benefit the most from diversification. Qatar and Kuwait rely heavily on hydrocarbon revenues. The Kuwaiti data are available from the same source for 2003 only. The shares are 0.46, 2.27, and 48.5 percent, respectively. We do not have similar data for Qatar or Bahrain.

For policy II, an introduction of a permanent 5 per cent VAT reduces welfare by around 4.6 per cent in terms of lifetime consumption equivalent. The positive change in the labor supply, resulting from the diversification policy, is greater in magnitude than the negative change resulting from the tax policy. One can only imagine a sizable welfare effect of a policy change larger than 0.25 standard deviations in hydrocarbon share in the economy. The point is clear: diversify and benefit.

4.2 Tax policy, labor supply and poverty reduction

Finally, we discuss the policy simulation pertinent to poverty reduction in the Arab countries. A decrease in the tax rate or the effective marginal income tax rate would increase the supply of hours, GDP, and reduce poverty. The policy simulation is intended to provide a feel for this policy recommendation. We want to answer questions such as, for example, how long would it take to reduce or eliminate poverty.

We choose Morocco as a case study for poverty for two reasons. Morocco's poverty level is high, 21 per cent of the population, and because we have some data on income distribution. The poverty data are based on the World Bank data found in POVNET for the year 2007 and the base year for real expenditures in 2005. For this reason we use data for real consumption and output from the Penn Table 6.3, which has data up to 2007 for Morocco and the base year is 2005.

We solve the model over the period 1991-2006, and simulate the model stochastically with 10000 iterations over the period 2008 to 2040. In the baseline solution, τ the effective marginal tax rate is equal 0.39. We set α to 1.78, which is the average we used earlier, and the share of capital θ equal to 0.55, which is also the average over the sample. Here, too, we guess that the capital stock's starting value is twice the size of real GDP in 1960. The depreciation rate was assumed to be 0.05. Consumption is assumed to be a random walk, with a standard normal error term of a zero mean and standard deviation equal to that of the sample average from 1991-2007. The value of the exogenous technical change A in the production function is the constant term, and calibrated such that the value of output in 2008 is not far from the value at 2007 in order to ensure we have a sensible projection. The policy reduces the tax rate to 0.30 permanently.

The simulated values of real consumption are used to compute poverty headcount. There are three parameters in the poverty function: mean real consumption expenditures; Gini coefficient; and the poverty line. The poverty line is fixed at 72 US dollars per household per month in PPP terms. The Gini coefficient is fixed. The only parameter that changes is mean real consumption expenditure, which is updated over the simulation period. We report the results in table 6. Figure 2 plots the poverty reduction dynamics.

Clearly, poverty could be reduced significantly. As income level rises, and growth rate of real consumption rises, poverty can be cut by more than half in 2020, i.e., in 12 years. Poverty can be eliminated by 2050. One can clearly advocate more tax reduction than the one we assumed, and cut poverty even faster and by more.

5. Conclusion

The work-leisure model of the labor supply has been tested extensively in the literature, and the majority of evidence seems to support its predictions. This paper uses data from Arab countries to confirm the predictions of the model and add more supporting evidence to existing ones. The supply of labor is elastic.

There are two types of Arab countries: non oil-producing, labor abundant countries such as Egypt, Jordan, Morocco, Syria, and Tunisia and major oil-producing, labor-scarce countries such as the Gulf Cooperation Council (GCC). Algeria is a major oil and gas producer, but not a labor-scarce country. While the model explains the data of the first group of Arab countries well, where results are comparable to the G7, the second group of Arab countries (the GCC) is more interesting because there are no taxes in these countries. Without taxes the model's performance and predictions are of limited value. To ameliorate this deficiency we introduce natural resource endowment effect in the work-leisure model. We define effective capital as the product of physical capital and natural resource capital. We found that natural resources endowment acts like a tax, i.e., reduce labor supply.

Oil rich GCC countries rely heavily on their natural resources as income. The government budget swells during periods of high oil and gas prices, which beget rents. The opposite happens when hydrocarbon revenues decline and the budgets shrink. People are forced to work longer hours to compensate for the loss in rent, and smooth out consumption. We show that the data support such a theory over periods of actual high and low hydrocarbon revenues. The supply of labor could decline by up to 7 hours a week per person during periods of high oil revenues.

The Arab countries labor supplies are very elastic, more so in the oil-producing countries. An elastic labor supply could imply less interventionist government policies. And as populations age, transfer payments to current and future old generations need not be financed by increasing tax rates. It can open doors to social security policies that encourage savings (Prescott, 2004). Elastic labor supplies are also good for demand policies that aim at increasing employment and hours.

We simulate the model for scenarios under a minimum number of additional assumptions. We demonstrate that a reduction in the effective marginal tax rate in the Arab countries can reduce poverty substantially, cut it in half in about 12 years in the case of Morocco.

High taxes, even a 5 percent increase in the value added tax (VAT), in the oil-rich countries would reduce welfare in terms of the lifetime consumption equivalent. But, most importantly, the model suggests that welfare significantly increases as oil revenues decline in oil-producing countries. To change the natural resource curse to a blessing, the GCC is strongly advised to diversify their income away from oil while they can. Our model indicates that a permanent reduction of hydrocarbon in the year 2020 could increase labor supply, real GDP, and consumption leading to a significant welfare improvement.

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Table 1: Actual and Predicted Labor Supply for the G7 and Arab non-oil Producing Countries

$h = (1-\bar{\theta})/(1-\bar{\theta}) + (c/y)(\bar{\alpha}/1-\tau)$

Estimates of the Labor Supply for the G7 (2000-2008)							
Country	Actual h	Predicted	Difference	α	θ	τ	c/y
Canada	25.26	23.60	1.66	1.78	0.38	0.38	0.70
France	20.08	22.73	-2.65	1.78	0.38	0.37	0.75
Germany	19.33	21.88	-2.54	1.78	0.38	0.42	0.73
Italy	21.09	22.45	-1.36	1.78	0.38	0.40	0.72
Japan	26.98	28.40	-1.41	1.78	0.38	0.25	0.66
UK	24.05	21.30	2.75	1.78	0.38	0.38	0.80
US	26.06	23.71	2.35	1.78	0.38	0.30	0.79
Average G7	**23.26**	**23.20**	**0.06**	**1.78**	**0.38**	**0.35**	**0.73**

Estimates of the Labor Supply for the Arab Countries (1999-2006)							
	Actual	Predicted	Frisch Elasticity	α	θ	τ	c/y
Egypt	NA	18.47	4.4	1.78	0.48	0.24	0.98
Jordon	NA	21.03	3.8	1.78	0.48	0.28	0.79
Morocco	NA	16.68	5.0	1.78	0.48	0.39	0.89
Syria	NA	26.10	2.8	1.78	0.48	0.19	0.67
Tunisia	NA	17.11	4.8	1.78	0.48	0.35	0.92
Average	**NA**	**19.87**	**4.1**	**1.78**	**0.48**	**0.28**	**0.85**

1. Both $\bar{\alpha}$ and $\bar{\theta}$ are the average values across G7 countries. The individual values of α for G7 which minimizes the error are 1.6 (Canada), 2.2 (France), 2.1 (Germany), 1.7 (Italy), 2.1 (Japan), 1.6 (UK) and 1.6 (USA) respectively. Same average value of α is adopted for the Arab countries.

Table 2: Productivity Decomposition of Arab Non-Oil Producing Countries Relative to Average G7 – Sample 1999 to 2006

Hours are based on a value of $\alpha = 1.78$

Country	GDP per Person	GDP per Hour	Hours per Person
Egypt	15.80	21.48	73.55
Jordan	12.73	15.17	83.89
Morocco	15.90	23.97	66.32
Syria	6.21	5.94	104.6
Tunisia	22.06	32.43	68.03
G7	100.00	100.00	100.00

Table 3: Labor Supply with Natural Resource Endowment for Oil Producing Countries $\hat{h}^N = (1-\theta-\omega)/[(1-\theta-\omega)+(c/y)(\alpha/1-\tau)]$

$(\alpha = 1.29)$

Low Hydrocarbon Revenue Period 1991-1999	$\hat{h}^N$	Frisch	τ	c/y	θ	ω	High Hydrocarbon Revenue Period 2000-2006 $\hat{h}^N$	Frisch	τ	c/y	θ	ω	Difference in hours
Algeria	20.4	3.9	0.34	0.73	0.47	0.19	13.2	6.6	0.38	0.61	0.55	0.27	-12.6
Bahrain	25.8	2.9	0.05	0.73	0.49	0.19	18.8	4.3	0.05	0.72	0.53	0.26	-7.0
Kuwait	12.8	6.8	0.05	0.81	0.49	0.36	7.2	12.8	0.05	0.71	0.53	0.40	-5.6
Oman	21.7	3.6	0.05	0.83	0.49	0.22	9.8	9.2	0.05	0.73	0.53	0.37	-11.9
Qatar	15.4	5.5	0.05	0.78	0.49	0.33	13.1	6.6	0.05	0.42	0.53	0.39	-2.30
KSA	16.9	4.9	0.05	0.74	0.49	0.32	7.9	11.7	0.05	0.65	0.53	0.40	-9.0
UAE	26.0	2.8	0.05	0.63	0.49	0.23	19.6	4.1	0.05	0.65	0.53	0.27	-6.4
Average	**19.8**	**4.43**	**0.05**	**0.75**	**0.49**	**0.29**	**12.72**	**8.14**	**0.05**	**0.65**	**0.53**	**0.35**	**-7.83**

$(\alpha = 1.55)$

Low Hydrocarbon Revenue Period 1991-1999	$\hat{h}^N$	Frisch	τ	c/y	θ	ω	High Hydrocarbon Revenue Period 2000-2006 $\hat{h}^N$	Frisch	τ	c/y	θ	ω	Difference in hours
Algeria	16.5	5.0	0.34	0.73	0.47	0.19	10.6	8.5	0.38	0.61	0.55	0.27	-5.9
Bahrain	21.2	3.7	0.05	0.73	0.49	0.19	15.2	5.6	0.05	0.72	0.53	0.26	-6.0
Kuwait	10.2	8.8	0.05	0.81	0.49	0.36	5.7	16.5	0.05	0.71	0.53	0.40	-4.5
Oman	17.6	4.7	0.05	0.83	0.49	0.22	7.7	11.9	0.05	0.73	0.53	0.37	-9.9
Qatar	12.4	7.1	0.05	0.78	0.49	0.33	10.5	8.6	0.05	0.42	0.53	0.39	-1.9
KSA	13.6	6.4	0.05	0.74	0.49	0.32	6.2	15.2	0.05	0.65	0.53	0.40	-7.4
UAE	21.4	3.7	0.05	0.63	0.49	0.33	15.9	5.3	0.05	0.65	0.53	0.27	-5.5
Average	**16.07**	**5.72**	**0.05**	**0.75**	**0.49**	**0.29**	**10.19**	**10.51**	**0.05**	**0.65**	**0.53**	**0.35**	**-5.0**

$(\alpha = 2)$

Low Hydrocarbon Revenue Period 1991-1999	$\hat{h}^N$	Frisch	τ	c/y	θ	ω	High Hydrocarbon Revenue Period 2000-2006 $\hat{h}^N$	Frisch	τ	c/y	θ	ω	Difference in hours
Algeria	13.3	6.5	0.34	0.73	0.47	0.19	8.40	10.9	0.38	0.61	0.55	0.27	-4.9
Bahrain	17.2	4.8	0.05	0.73	0.49	0.19	12.20	7.2	0.05	0.72	0.53	0.26	-5.0
Kuwait	8.1	11.4	0.05	0.81	0.49	0.36	4.50	21.4	0.05	0.71	0.53	0.40	-3.6
Oman	14.2	6.0	0.05	0.83	0.49	0.22	6.10	15.4	0.05	0.73	0.53	0.37	-8.1
Qatar	9.9	9.1	0.05	0.78	0.49	0.33	8.30	11.1	0.05	0.42	0.53	0.39	-1.6
KSA	10.9	8.2	0.05	0.74	0.49	0.32	4.90	19.5	0.05	0.65	0.53	0.40	-6.0
UAE	17.4	4.7	0.05	0.63	0.49	0.23	12.8	6.8	0.05	0.65	0.53	0.27	-4.4
Average	**12.96**	**7.38**	**0.05**	**0.75**	**0.49**	**0.29**	**8.11**	**13.56**	**0.05**	**0.65**	**0.53**	**0.35**	**-4.8**

θ is the share of capital. τ is the effective marginal tax rate; c/y is consumption to GDP ratio; $\hat{h}^N$ is equilibrium hours-worked predicted by the model; and ω is the share of hydrocarbon revenues in GDP.

Table 4: Taxes, Natural Resources and Labor Supply Projections for GCC
Average values

Country	Average Sample Data (1991-2003)			Base Run (2004-2050)			Policy I (2020 – 2050)				Policy II (2004 – 2050)		
	ω	σ_ω	c/y	h^N	ω	c/y	h^N	ω	$0.25\sigma_\omega$ in million USD	τ	h^N	ω	τ
Bahrain	0.22	0.04	72.5	16.4	0.25	71.0	17.1	0.24	153.3	0.05	15.7	0.25	0.095
Kuwait	0.38	0.07	83.7	11.4	0.35	64.3	12.5	0.33	1017.2	0.05	10.9	0.35	0.095
Oman	0.26	0.07	79.5	7.4	0.39	73.3	8.8	0.37	839.8	0.05	7.0	0.39	0.095
Qatar	0.37	0.07	65.7	13.4	0.36	39.2	14.8	0.35	351.7	0.05	12.8	0.36	0.095
KSA	0.32	0.04	70.7	16.2	0.29	60.4	17.0	0.28	3812.9	0.05	15.6	0.29	0.095
UAE	0.30	0.07	63.5	18.7	0.23	66.1	19.9	0.21	2187.5	0.05	18.0	0.23	0.095
GCC	**0.31**	**0.06**	**72.6**	**13.9**	**0.31**	**62.38**	**15.0**	**0.30**	**1393.7**	**0.05**	**13.6**	**0.31**	**0.095**

h_t^N is hours-worked (equation 10).

ω is the share of oil and gas (gas is converted into oil using the standard scale of 6.6).

σ_ω is the standard deviation of the natural resource revenues in GDP.

c/y is the consumption to GDP ratio.

τ is the tax rate.

Consumption and ω follow a random walk process over the simulation horizon from 2004 to 2050.

Policy I is the diversification policy, where the GCC manages to diversify by 2020, and reduce the share of hydrocarbon by 0.25 σ_ω .

Policy II is a tax rate increase policy, where a 5% permanent increase in VAT (9.5 percent in the tax rate in equation 5).

Table 5: Lifetime Consumption Equivalent

Country	Policy I	Policy II
Bahrain	3.87	- 4.79
Kuwait	9.29	- 4.80
Oman	13.99	- 3.77
Qatar	10.88	- 4.78
KSA	4.21	- 4.81
UAE	5.07	- 4.82

- Policy I is the diversification policy, where the share of hydrocarbon in GDP falls by 0.25 standard deviation from 2021 to 2050.
- Policy II is an introduction of a 5 percent permanent increase in VAT, which amounts to a 9.5 percent increase in the tax rate.

Table 6: Morocco's Poverty Reduction Policy Simulation

	Hours		GDP Per Capita		$\partial y / d\tau$	Income Multiplier	Δc_t^s	Poverty %
2007	Baseline	Policy	Baseline	Policy				21.59 [i]
2008	15.99	17.97	5682.52	6014.69	-1.27	5.85	2.26	20.48
2010	15.96	17.94	5905.58	6280.19	-1.15	6.34	2.58	18.27
2015	15.97	17.95	6487.00	6967.58	-0.94	7.41	1.69	14.72
2020	15.92	17.90	7076.94	7662.59	-0.81	8.28	1.20	10.50
2025	15.93	17.91	7703.77	8395.41	-0.72	8.98	2.68	7.57
2030	15.92	17.90	8356.12	9154.61	-0.66	9.56	1.51	5.61
2035	15.93	17.91	9042.68	9949.86	-0.62	10.03	1.74	4.01
2040	15.94	17.92	9767.29	10785.58	-0.58	10.43	1.37	2.92
2045	15.93	17.91	10527.96	11659.88	-0.56	10.75	1.31	2.11
2050	15.92	17.90	11328.41	12577.27	-0.53	11.02	1.46	1.54

i Actual data

-Data are in PPP 2005 base year. Real PPP GDP.

-$\partial y / d\tau$ is the tax multiplier, where an increase in the tax rate reduces income.

-$(y^s - y^b / y^b)100$ is the GDP multiplier, where the superscript s denotes simulation solution value and b denotes the baseline simulation value.

-Δc_t^s is the consumption growth after policy.

Appendix 1 – Data

Average 2000-2008	Canada	France	Germany	Italy	Japan	UK	USA
General government final consumption expenditure, %GDP	19.24	23.31	18.70	19.62	17.86	20.54	15.58
Consumption of fixed capital, % GDP	13.01	13.00	14.89	15.28	20.62	11.26	11.85
Household final consumption expenditure, % GDP	55.84	56.46	58.47	59.04	57.08	64.88	70.03
Working Age Population to Total Population	0.69	0.63	0.67	0.67	0.66	0.66	0.67
Employment to Age working population	0.72	0.65	0.67	0.58	0.75	0.71	0.72
Taxes individuals, % GDP	12.23	7.64	8.91	10.72	5.19	10.48	10.38
Social Security Contributions, Employees % GDP	2.01	4.02	6.11	2.30	4.28	2.64	3.00
Taxes on goods and services, % GDP	8.42	11.00	10.35	11.01	5.22	10.97	4.73
Military Expenditure, % GDP	1.20	2.46	1.38	1.92	0.97	2.46	3.76
τ_c	0.16	0.22	0.20	0.20	0.09	0.19	0.07
τ_{ss}	0.04	0.07	0.11	0.05	0.07	0.04	0.05
Capital Share	0.38	0.35	0.38	0.46	0.35	0.34	0.37
τ_{inc}	0.16	0.10	0.12	0.15	0.07	0.13	0.12
τ_h	0.28	0.23	0.30	0.28	0.18	0.26	0.25
τ	0.38	0.37	0.42	0.40	0.25	0.38	0.30
c/y	0.70	0.75	0.73	0.72	0.66	0.80	0.79
GDP Per Person, GDP Less IT in PPP 2005 divided By Population aged 15-64	42510.72	38698.09	37867.03	35733.27	40045.97	39364.55	57049.32

Source: OECD

Data Appendix (average 1991-2006)

Country	Actual Weekly Worked Hours	Capital Share	Consumption Output Ratio, PWT 6.2 (1991-2003/04)	Investment Ratio, PWT 6.2 (1991/03/04)	Population (Millions)	Labor force (Millions)	Employment (Millions)	Population Aged 15-64 % Total Population	Employment to Population Aged 15-64
Algeria		0.51	0.69	12.67	29.79	10.46	8.01	60.14	0.44
Bahrain		0.35	0.73	9.89	0.63	0.29	0.27	68.50	0.64
Egypt		0.45	0.96	5.41	64.91	19.24	17.35	58.89	0.45
Kuwait		0.57	0.84	10.67	2.05	1.08	1.09	70.99	0.74
Jordan		0.36	0.77	14.39	4.60	1.23	1.21	68.35	0.38
Morocco		0.56	0.90	11.52	27.76	9.56	8.55	60.67	0.51
Oman		0.53	0.80	9.30	2.29	0.82	0.76	59.81	0.55
Qatar		0.50	0.66	18.70	0.61	0.34	0.33	73.49	0.72
KSA		0.51	0.71	9.96	20.06	6.64	6.34	58.67	0.54
Syria		0.33	0.73	7.79	16.06	4.73	5.09	55.11	0.57
Tunisia		0.24	0.92	13.35	9.33	3.09	2.71	62.78	0.46
UAE		0.61	0.63	23.12	3.04	1.75	1.72	73.98	0.75
Source	ILO	UN	WDI-PWT	PWT	WDI	WDI	ILO	WDI	ILO

country	Employment to total population Ratio	Oil and Gas Reserves, Billions Barrels of Equivalent Oil	GDP Per Capita PPP PWT 6.2 (1991/03/04)	τ_c	τ_{ss}	τ_{inc}	$\tau_{inc} + \tau_{ss}$	τ	ω Share of Hydrocarbon Revenues
Algeria	0.27	38.0	4826.0	0.18	0.05	0.10	0.21	0.33	0.23
Bahrain	0.44	0.8	15562.4	0.00	0.04	0.01	0.05	0.05	0.22
Egypt	0.27	11.5	3955.0	0.09	0.05	0.08	0.17	0.24	
Kuwait	0.53	107.7	21698.5	0.00	0.04	0.00	0.04	0.04	0.32
Jordan	0.26		3835.6	0.16	0.04	0.08	0.16	0.28	
Morocco	0.31		3630.0	0.19	0.10	0.11	0.28	0.39	
Oman	0.33	9.7	13127.0	0.00	0.04	0.01	0.05	0.05	0.20
Qatar	0.53	113.6	23284.6	0.00	0.03	0.00	0.03	0.03	0.35
KSA	0.31	302.4	14086.7	0.00	0.06	0.00	0.04	0.04	0.25
Syria	0.31	4.3	1799.0	0.00	0.00	0.12	0.20	0.19	0.06
Tunisia	0.29	0.4	6296.2	0.22	0.05	0.08	0.16	0.31	0.04
UAE	0.56	137.8	24455.5	0.00	0.04	0.00	0.02	0.01	0.26
Source	ILO	BP	PWT	WDI, IFS	SS	WDI, IFS	Computed	Computed	WDI, IFS

ILO is the International Labor Organization
BP is British Petroleum
PWT is Penn World Table 6.3
WDI is World Bank
IFS is International Financial Stats, the IMF

Figure 1: Labor and Natural resource Wedge

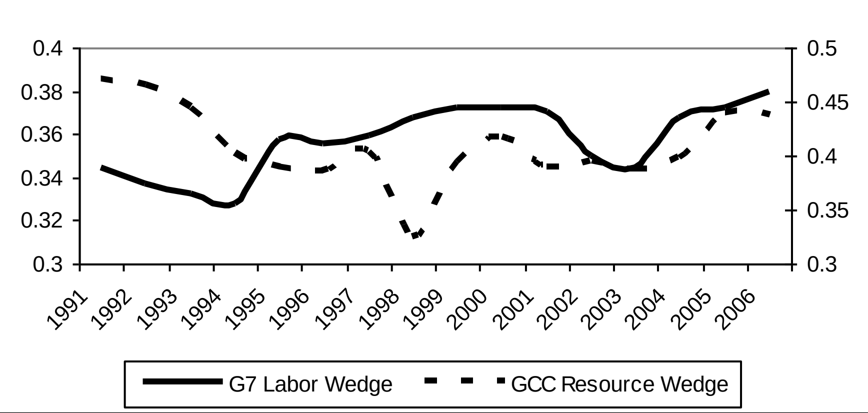
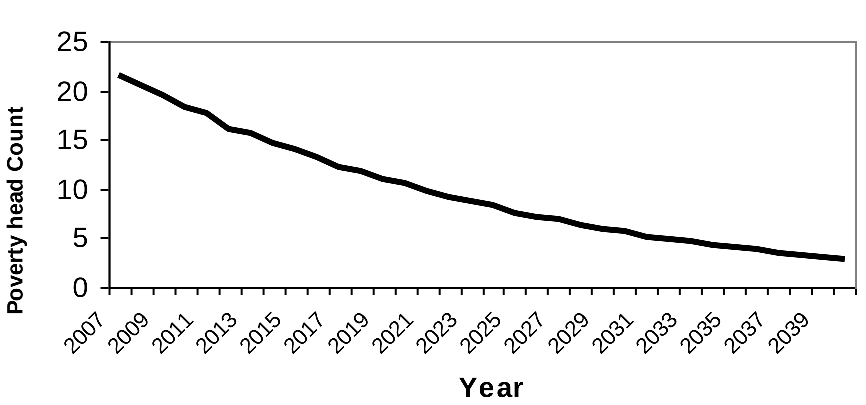


Figure 2: Pro Poor Fiscal Policy Morocco



Appendix 2 – Calculating the tax rate

Prescott (2004) adjusts the National Income Account to fit with economics theory, where households pay the taxes. The major adjustment is to treat "indirect taxes less subsidy" as "net taxes on final product". It means "net indirect tax" is not a cost component of GDP. Indirect taxes include value-added taxes, sales taxes, excise taxes, property taxes…etc, which mostly levied on households. Some indirect taxes such as diesel fuel taxes, property taxes on office buildings and sales taxes on equipments…etc fall on all forms of products. It is assumed that 2/3 of the indirect taxes less subsidy fall directly on private consumption expenditures, and the remaining 1/3 is distributed evenly over private consumption and private investment. The net indirect taxes on consumption, is $IT_c = [2/3 + 1/3\frac{C}{C+I}]IT$, where C is private consumption expenditures, I is private investment, and IT is net indirect taxes. Consumption is $c = C + G - G_{mil} - IT_c$, where G is public consumption and G_{mil} is military spending. The GDP is given by $y = GDP - IT$. Prescott (2004) estimate of consumption tax rate is $\tau_c = \frac{IT_c}{C - IT_c}$. Regarding tax on labor income, Prescott (2004) has two: the income tax with a marginal tax rate τ_{inc} (which we argued earlier in the paper that its estimation is highly controversial), and a social security tax. The social security marginal tax rate $\tau_{ss} = \frac{social\ \mathrm{sec}urity\ taxes}{(1-\theta)(GDP - IT)}$, where the denominator is labor income if labor is paid its marginal productivity. The *average* income tax rate is $\bar{\tau}_{inc} = \frac{Direct\ Taxes}{GDP - IT - Depreciation}$, where direct taxes are paid by households and do not include corporate income taxes. Prescott's estimate of the marginal labor income tax $\tau_h = t_{ss} + 1.6\bar{\tau}_{inc}$ and the magic number 1.6 reflects the fact that the marginal income tax rates are higher than the average tax rates, and the number delivers a marginal income tax found in Feenberg and Coutts (1993) for the "US". Their calculation of the marginal income tax is based on a representative sample of tax records. They calculate by how much the tax revenue increases if every household labor income is increased by one percent. The total change in tax receipts divided by the total change in labor income is their estimate of the marginal income tax.

Sensitivity Analysis of the Effective Marginal Tax Rate Calculations

	Lower Bound Estimate		Central Estimate		Upper Bound Estimate			
Country	τ_1	h	τ_2	h	τ_3	h	τ_4	h
Algeria	0.28	17.8	0.33	16.8	0.41	15.1	0.50	13.1
Egypt	0.20	21.5	0.24	20.6	0.31	19.1	0.38	17.5
Jordan	0.24	24.4	0.28	23.4	0.34	21.9	0.41	20.0
Morocco	0.34	19.9	0.39	18.6	0.49	16.1	0.58	13.7
Syria	0.12	30.6	0.19	28.8	0.32	25.4	0.44	21.9
Tunisia	0.30	20.3	0.35	19.2	0.43	17.2	0.51	15.1
Average	**0.24**	**22.4**	**0.28**	**21.3**	**0.44**	**19.1**	**0.45**	**16.8**

τ_1 corresponds to a tax rate with $\tau_h = t_{ss} + 1\bar{\tau}_{inc}$

τ_2 corresponds to a tax rate with $\tau_h = t_{ss} + 1.6\bar{\tau}_{inc}$

τ_3 corresponds to a tax rate with $\tau_h = t_{ss} + 2.6\bar{\tau}_{inc}$

τ_4 corresponds to a tax rate with $\tau_h = t_{ss} + 3.6\bar{\tau}_{inc}$

See definitions of the social security tax and tax on income in the appendix. τ_{ss} τ_{inc}

$h = (1-\theta)/[(1-\theta) + (c/y)*(\alpha/1-\tau)]$ are hours-worked using predicting factors $\theta = 0.48$;

average Arab countries c/y and $\alpha = 1.55$

[i] Prescott (2004) provide evidence that – everything else constant – significant differences in international hours-worked almost disappear when tax rates are similar. Scandinavians pay relatively more taxes. Ragan (2006) and Rogerson (2007) argued that Scandinavian governments subsidize market inputs into home production and provide more transfers (e.g. subsidized daycare) to households that supply more labor. Olovsson (2009) use home production data to account for the differences in hours-worked between Scandinavians and others.

[ii] Lucas and Rapping (1969), Hall (1980), Andrew and Nickell (1982), Alogoskoufis (1987a, 1987b), Dutkowsky and Dunsky (1996), Nickell (2003), Prescott (2004), and Shimer (2009) among many others provided evidence that support the model. Card (1991) cited a number of surveys at the micro level, which seem to suggest that the intertemporal substitution proposition offers little explanation to labor supply decisions. Heckman (1993) cited more supportive evidence. The literature is voluminous, but most cited work evidence against the intertemporal substitution model are, Altonji (1982), Mankiw, Rotemberg and Summers (1985)

[iii] Prescott cites a number of papers as the basis of this theory; business cycle literature Cooley (1995) and Cooley and Ohanian (1999); in the depression literature he cites Kehoe and Prescott (2002); in public finance, Christaino and Eichenbaum (1992), Baxter and King (1993); and in the stock market literature McGrattan and Prescott (2003) and Boldrin, Christian and Fisher (2001). The labor supply is consistent with Lucas and Rapping (1969), Lucas (1972), Kydland and Prescott (1982), Hansen (1985) and Auerbach and Kotlikoff (1987).

[iv] It is hard to imagine a process for A_{it} in the Arab countries.[iv] The stock of R&D stock and patents registered in the US are very low. Saudi Arabia, Egypt, Syria, Jordan, Kuwait and the UAE combined registered 367 patents in the US during the period from 1980 to 2000. Compare that to Korea which registered 6328 patents. Human capital stock and the quality of the human capital are questionable, see Development Challenges for the Arab Region: A Human Development Approach, UN (2009).

[v] There is a literature on the methods of estimating average marginal income tax rates in the US, where differences seem significant. Differences in the computation of income tax rates could affect the tax rate τ in model. For more on the debate, see Barro (1979), Seater (1982), Barro and Sahasakul (1983, 1986), Stephenson (1998), and Akhand and Liu (2002).

[vi] It is east to see where equation (5) come from. Setting up the Langrange

multiplier and taking derivatives with respect to c and h, we get:

$$\partial L/\partial c = (1/c) - \lambda(1+\tau_c) = 0 \Rightarrow \lambda = \frac{1}{c(1-\tau_c)};$$

$$\partial L/\partial h = \alpha/(100-h) - \lambda(1+\tau_h)w = 0 \Rightarrow \lambda = \frac{\alpha}{(1-\tau_h)(100-h)}\frac{1}{w}$$

$$\frac{\frac{\alpha}{100-h}}{\frac{1}{c}} = (\frac{1-\tau_h}{1+\tau_c})w = (1-\frac{\tau_h+\tau_c}{1+\tau_c})w = (1-\tau)w$$

vii $$(1+\tau_c)c_t + (1+\tau_x)x_t = (1-\tau_h)w_t.h_t + (1-\tau_K)(r_t - \delta)k_t + \delta k_t + T_t + (P_t^o N_t / \hat{P}_t),$$
where P_t^o is the international price of the natural resource, N_t is the flow of natural resources, and $\hat{P}_t$ is population.

viii One could easily allow these parameters to change across countries, but we fix them because we are comparing hours in the Arab countries to the G7 hours, which are the yardstick for the fit of the model.

ix When solving, an approximated Jacobian is used when linearizing the model. Then the approximation is updated each iteration by comparing the residuals, which result from the new trial value of the endogenous variables with the residuals of the linear equation. The method is not significantly different from Newton, but it runs faster. The innovations to stochastic equations are generated by drawing a set of random numbers from a standard normal distribution each period. These draws are scaled to match the variance-covariance system by multiplying the vector by its standard deviation because the covariance matrix is diagonal.

x The Penn table 6.2 data are only available to the year 2003 for the GCC countries.