TWO ESSAYS ON MACROECONOMICS

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DECLARATION OF ORIGINALITY

I, Tuğçe Türk, certify that

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ABSTRACT

Two Essays on Macroeconomics

This thesis is composed of two essays on macroeconomics. In the first one, the aim is to understand the role of the informal sector in determining countries' access to the world technology frontier as well as to their own technology frontiers. It is found that incorporating the informal economy alters the measurement of the formal TFP significantly. For 2006, the difference between TFP obtained from classical one sector model and the formal TFP obtained from the model with informality is 25%. Both formal and informal labor efficiencies are positively related to income levels of countries. When technology frontiers of each country are investigated, it is found that access to the world technology frontier results in 38% decrease in income differences among countries. In the second essay, I investigate the behavior of the marginal cost of public funds (MCF) using different taxes under the presence of informality. To this end, I build a dynamic general equilibrium model with formal and informal sectors and allow the government to use consumption, capital, and labor income taxes to raise the revenue needed to finance government purchases. Then, I use the simulations of the model to evaluate how the MCF is associated with informality level of countries. Finally, using country-level data on taxes, we calibrate and measure MCF for a panel of developed and developing countries.

ÖZET

Makroekonomi Üzerine İki Makale

Bu tez makroekonomi üzerine iki makaleden oluşmaktadır. İlk makale, kayıtdışı sektörün ülkelerin kendi ve dünya teknoloji sınırına erişimindeki rolünü anlamayı amaçlamaktadır. Kayıtdışı ekonominin varlığının kayıtlı Toplam Faktör Verimliliği (TFV) ölçümleri üzerinde önemli bir etkisi olduğu bulunmuştur. 2006 yılı için bakıldığında tek sektörlü klasik modelden elde edilen TFV ve kayıtdışı ekonominin olduğu modelden elde edilen kayıtlı TFV arasındaki fark $\%25$'tir. Hem kayıtlı hem de kayıtdışı işgücü verimliliği ile ülkelerin geliri arasında pozitif bir ilişki vardır. Teknoloji sınırları incelendiğinde, dünya teknoloji sınırına erişimin ülkeler arası gelir farkını $\%38$ azalttığı görülmektedir. İkinci makalede, Kamu Fonlarının Marjinal Maliyeti (KFMM)'nin kayıtdışı ekonomi varlığı altında farklı vergiler için nasıl değiştiğini inceledim. Kayıtlı ve kayıtdışı sektörlerin olduğu bir dinamik genel denge modeli kurdum. Bu modelde devlet tüketim, sermaye geliri ve işgücü gelirine vergi uygulayarak devlet alımları için gerekli geliri toplayabilmektedir. Modeli simüle ederek KFMM'nin kayıtdışılık seviyesi ile olan ilişkisini inceledim. Son olarak, ülkeler arası vergi verisi kullanarak modeli kalibre ettim ve gelişmiş ve gelişmekte olan ülkelerin KFMM'sini hesapladım.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDIX TABLES

LIST OF FIGURES

LIST OF APPENDIX FIGURES

CHAPTER 1

ACCESS TO THE TECHNOLOGY FRONTIER: THE ROLE OF INFORMALITY

1.1 Introduction

A well-known result emerging from growth literature is that Total Factor Productivity is the main source of the income differences across countries. (Prescott,1998 and Klenow et al., 1997). Accounting for production factor differences other than TFP cannot explain the big discrepancies among countries. The contribution of TFP on growth is outstanding compared to the contribution of capital and labor.

While the importance of TFP is evident, measuring it precisely is hard to accomplish. As it stands for the remaining part of the income after capital and labor are accounted, it is vulnerable to the factors that may change the measurements of the production factors and informality is one of them. In this paper, one of the aims is to obtain more accurate measures for the productivity of countries by incorporating the informal economy.

Informal economy has a substantial share in various economies. Elgin and Oztunali (2012) found that GDP-weighted informal economy size of the world is 27.9%. Also, this number is higher in the developing countries where understanding the constraints on the growth is very decisive. Thus, in order to see the real differences in productivity across countries, the informal economy should also be taken into account in calculations. As productivity patterns of the formal and the informal part of the economy are different, separating those two gives a better understanding of real productivity differences across countries.

There are several channels that are investigated in the literature which affect the productivity of a country through informality. One of the most outstanding facts about the relationship between informality and productivity is that informal firms are not as

productive as formal firms (Dabla-Norris et al., 2005). One of the key reasons that may result in efficiency differences between formal and informal sectors is that informal firms cannot access to credit market which is a major determinant of the growth of a firm (Gatti & Honorati, 2007). Also, informal firms cannot benefit from government subsidies that may help their productivity to increase. In addition to this, the scale factor is a crucial determinant for informal firms to lag behind of the formal sector in terms of productivity. De Soto (1989) claims that informal firms choose to keep their size smaller in order to not to be detected by authorities. Having a smaller size prevents firms to get an advantage of economies of scale which results to operate inefficiently. La Porta et al. (2008) also states that having managers with higher education level is a prominent aspect of the formal sector which may have an effect on the productivity of those firms.

Along with lack of efficiency in the informal sector, the existence of it also alters the efficiency of the formal sector. Busso et al. (2012) claim that informality generates distortions in the labor market which result in a reduction in total factor productivity of the economy. Levya et al. (2017) find that the existence of informal labor absorbs the shocks in the economy and decrease the macroeconomic volatility, but the cost incurred is low TFP and output levels. However, there are also opposite ideas about the effect of informality on formal sector efficiency in the literature. Although being formal is advantageous for a firm as they can access to credits easily and operate in big scales, it comes with costs also. DErasmo and Boedo (2011) explain that the firms that cannot pay the cost of being formal, that are generally less efficient firms, operates informally. Thus, the costs work as a selection mechanism which results in formal firms being more productive on average, as frictions decreases. Thus, they found that model without informality generates less TFP level

than the formal sector TFP in the model with informality. Thus, the effect of informality on productivity is not assured in the literature. Ulyssea (2014) found that lower informality is not necessarily associated with high level of TFP.

The framework that Caselli and Coleman (2002, 2006) use in their paper is the building block of this paper. They use the constant elasticity of substitution production function with two types of labor to investigate the efficiency of skilled and unskilled labor with cross-country data. They also construct technology frontiers to show the choice of each country's production technology that utilizes skilled or unskilled labor more depending on their optimality in terms of labor endowments. The same structure is used for investigating the formal and informal labor efficiencies. The model introduced in this paper is also adopted by Atesagaoglu et al. (2017) in order to see how informality affects both the level as well as the growth path of the total factor productivity of Turkey in a time period of 1950-2014. They found that standard TFP calculation mostly underestimates the formal TFP compared to two labor model. One of the aims of this paper is to find whether this pattern is specific to Turkey or it can be seen in various economies.

In this paper, informality is embedded to model through labor. Different from most of the literature that model informality as a different sector, this model uses a constant elasticity of substitution production function where formal and informal labor can substitute each other but not perfectly. By using a cross-country data, each country's formal and informal labor productivity is calculated. The most outstanding finding is that classical estimation methods for total factor productivity underestimate the formal labor TFP significantly. In addition to this, it is found that richer countries use both formal and informal labor more efficiently. Also, a counterfactual analysis reveals that technology frontiers of the countries are one of the main determinants of

the income differences across countries. Thus expanding the set of possible technologies for countries can improve their well-being.

1.2 Model

As a benchmark model, a standard neoclassical production technology is used with only formal labor. Then, to see the impact of the informality on productivity, informal labor is also added to the production technology. In order to see whether chosen production technology affects the results or not, two types of function -one level CES and two-level CES- are used in two labor model.

1.2.1 Model with only formal labor

TFP levels in growth literature are mostly measured by calculating the number that explains the discrepancy between factor endowments and income. Production function that is used in the benchmark model is a constant returns to scale Cobb-Douglass production function as follows:

$$Y_t = (K_t)^{\alpha}(A_t L_t)^{1-\alpha}$$

where A_t, K_t and L_t denote, respectively, the productivity, the stock of capital and the input of labor. It can be seen that production function adopt a labor augmenting productivity. It is assumed in that way because the comparison of formal and informal labor can be done conveniently.

Based on the production technology given, the productivity measure A_t can be backed up from the following equation:

$$A_t = \left[\frac{Y_t}{(K_t)^{\alpha}(L_t)^{1-\alpha}}\right]^{(\frac{1}{1-\alpha})}$$

In this calculation, Y_t stands for only the formal output level. As this calculation is used as a benchmark, it is calculated with the standard data on the formal economy.

1.2.2 Models with formal and informal labor

In this section, informal labor is incorporated into neoclassical production function. Following Caselli and Coleman (2002, 2006), two alternative CES production technologies are used. Those two functions are explained in detail in the following sections.

1.2.2.1 One level CES production technology

In this model, it is assumed that the output Y_t, which is now a combination of formal and informal output, is produced according to the following CES production technology

$$Y_t = (K_t)^{\alpha} \left[(A_t^F L_t^F)^{\sigma} + (A_t^I L_t^I)^{\sigma} \right]^{\frac{1-\alpha}{\sigma}},$$

where L_t^F is formal labor, L_t^I is informal labor, A_t^F is productivity level of formal labor, A_t^I is productivity level of informal labor. It can be seen that when informality becomes zero, the production function turn into the one in the benchmark model. Hence, the productivity level that is found in benchmark model is the same with A_t^F if informality is assumed to be zero. The elasticity of substitution between formal and informal labor is equal to $1/(1-\sigma)$ and it is assumed $\sigma < 1$. When $\sigma = 1$, formal and informal labor are perfect substitutes. This implies that only the formal labor, which is assumed to be more productive, is used in the production. In that case, the model again becomes same with the benchmark model.

By assuming marginal productivity levels are paid for each production factor, closed form solution of this optimal allocation problem is found. Thus, we can obtain

A_t^F and A_t^I. Let w_t^F, w_t^I and r_t denote, respectively, the formal wage, informal wage and marginal productivity of capital stock. Then, the closed form solutions of A_t^F and A_t^I as follows:

$$A_t^F = \left[\frac{(Y_t)^{\frac{1}{1-\alpha}}(K_t)^{\frac{-\alpha}{1-\alpha}}}{L_t^F}\right]\left(\frac{w_t^F L_t^F}{w_t^F L_t^F + w_t^I L_t^I}\right)^{1/\sigma}$$

$$A_t^I = \left[\frac{(Y_t)^{\frac{1}{1-\alpha}}(K_t)^{\frac{-\alpha}{1-\alpha}}}{L_t^I}\right]\left(\frac{w_t^I L_t^I}{w_t^F L_t^F + w_t^I L_t^I}\right)^{1/\sigma}$$

The productivity level A^F is the measurement that is compared with the productivity level in the benchmark case.

1.2.2.2 Two level CES production technology

In this model, it is assumed that the output Y_t, which is again a combination of formal and informal output, is produced according to the following CES production technology

$$Y_t = \{(A_t^I L_t^I)^\sigma + \left[(A_t^F L_t^F)^\rho + (A_t^K K_t)^\rho\right]^{\frac{\sigma}{\rho}}\}^{\frac{1}{\sigma}},$$

where L_t^F is formal labor, L_t^I is informal labor, A_t^F is productivity level of formal labor, A_t^I is productivity level of informal labor, A_t^K is productivity level of capital, $\sigma < 1$ and $\rho < 1$. The elasticity of substitution between formal labor and capital is equal to $1/(1-\rho)$. In this model, again the elasticity of substitution between formal and informal labor, and also between capital and informal labor, is equal to $1/(1-\sigma)$.

As in one level CES function case, the closed form solutions for A_t^F, A_t^I and A_t^K can be obtained by assuming that all factors of productions are paid their marginal productivity. Let w_t^F, w_t^I and r_t denote, respectively, the formal wage, informal wage

and the marginal productivity of capital stock. The closed form solutions for A_t^F, A_t^I and A_t^K as follows:

$$A_t^F = \frac{Y_t}{L_t^F}\left(1 - \frac{r_t(\frac{K_t}{Y_t})}{S_t}\right)^{1/\rho} {S_t}^{1/\sigma}$$

$$A_t^I = \frac{Y_t}{L_t^I}\left(1 - S_t\right)^{1/\sigma}$$

$$A_t^K = \left(\frac{r_t(\frac{K_t}{Y_t})^{1-\rho}}{S_t}\right)^{1/\rho} {S_t}^{1/\sigma}$$

where

$$S_t = \frac{\frac{w_t^F L_t^F}{w_t^I L_t^I} + r_t(\frac{K_t}{Y_t})}{\frac{w_t^F L_t^F}{w_t^I L_t^I} + 1}$$

In this model also the productivity level A^F is the measurement that is compared with the productivity level in the benchmark case.

1.2.3 Technology frontier

In the production of the goods, it is assumed that there is no fixed production technology for each country. Instead, there are set of different technologies available for each country in which they choose the appropriate one among them conforming with their labor endowments. Those set of technologies are represented by a technology frontier. All technology bundles that are in below the frontier are dominated by the bundles on the frontier in terms of efficiency and technology bundles above the technology frontier are not feasible for the country. Thus each frontier shows the technology boundary for a country. In order to find the technology frontier, a representative firm is used. Representative firm solves profit maximization

problem which is subject to a constraint that represents the boundary of efficiency level.

$$\max_{A_t^F, A_t^I} \pi_t = Y_t - w_t^F L_t^F - w_t^I L_t^I - r_t K_t$$

subject to

$$(A_t^F)^\omega + \gamma (A_t^I)^\omega \leq B$$

Every firm, so every country, chooses an efficiency bundle (A_t^F, A_t^I) from its own technology frontier. Thus, B is the main determinant for the efficiency choice and defines the boundary on technology adoption.

1.3. Data and calibration

The data used in the calculations are from 2002 to 2006. Due to data limitations, it covers 42 to 50 countries, which varies from year to year. The level of capital stock K_t, formal labor L_t^F, and formal output Y_t^F are from Penn World Tables. The data on informal labor L_t^I and informal output Y_t^I are obtained from Elgin and Oztunali(2012).

Formal sector wages w_t^F are taken from Extended Penn World Table. Unfortunately, there is no comprehensive data for informal wage w_t^I. Gindling et al (2016) provide wage gaps in the formal and informal sector for 36 countries. In order to expand the data, a relationship between agricultural wage and informal wage is found for those 36 countries. Then by using this relationship and agricultural wage data for other countries, an informal wage data is constructed. Before choosing agricultural wage, other indicators are also experimented such as minimum wage, informality size, GDP level. However, agricultural wage turned out to be the best among those with high correlation with the informal wage.

For Model 2, the marginal productivity of capital stock, r_t, is equal to the real interest rate plus the rate of depreciation on physical capital. Real interest rate data is constructed with deposit interest rate data minus the inflation rate, both of the data from World Development Indicators and the depreciation rate δ data is taken also from Penn World Table. For the capital share parameter α, two constant values are used for two different set of countries. First countries are divided into two different income groups. For low-income countries, the capital share is taken as 1/2 and the high-income countries it is taken as 1/3.

As there is no estimated $1/(1-\sigma)$ values in the literature, which defines the substitution elasticity of formal and informal labor, it is calculated with the method that Bowles(1970) defines in his paper. The resulting σ level obtained from the panel-data regression is 0.88. In addition to this, it is also calculated from the survey data containing firm-level information about informal sector in Turkey (Elgin and Sezgin, 2017). The estimation result gives the σ value as 0.7. In order to check the robustness of the results across different σ values, both of them are used in the calculation. From this robustness check, it can be said that the main results are not affected by the σ value. To estimate the elasticity of substitution between capital and formal labor $1/(1-\rho)$, panel data regression is used by following the method in the Antras(2004). The obtained value for ρ is 0.27. The value of σ is bigger than ρ shows that substitution between formal labor and informal labor is higher than the substitution between formal labor and capital.

As the parameters in technology frontiers are model specific, they are estimated from first order optimality conditions of the profit maximization problem. In Model 1,

the equation that describes the optimal efficiency bundle is that:

$$\gamma \left(\frac{L^F}{L^I} \right)^{\sigma} = \left(\frac{A^F}{A^I} \right)^{\omega - \sigma}$$

when the logarithm of this equation is taken, the relation between labor ratio and efficiency ratio becomes linear. Thus ω, γ and B can be obtained with a panel data regression by using the equation below.

$$log \left(\frac{A^F}{A^I} \right) = \frac{\sigma}{\omega - \sigma} log \left(\frac{L^F}{L^I} \right) + \frac{1}{\omega - \sigma} log(\gamma)$$

$$\gamma [(A^F L^F)^{\rho} + (A^K K)^{\rho}]^{\frac{\sigma}{\rho} - 1} \frac{(A^F L^F)^{\rho}}{(A^I L^I)^{\sigma}} = \left(\frac{A^F}{A^I} \right)^{\omega}$$

when the logarithm of this equation is taken, the relation becomes linear. Thus ω, γ and B can be obtained with a panel data regression by using the equation below.

$$log \left(\frac{A^F}{A^I} \right) = \frac{1}{\omega} log \left(\gamma [(A^F L^F)^{\rho} + (A^K K)^{\rho}]^{\frac{\sigma}{\rho} - 1} \frac{(A^F L^F)^{\rho}}{(A^I L^I)^{\sigma}} \right)$$

1.4. Results

1.4.1. Model 1

One of the aims of this paper is to find how incorporating the informal sector affects the measurement of the formal labor TFP. When TFP obtained from benchmark case A_t and the formal labor TFP obtained from one level CES model A_t^F are compared, it is found that benchmark model cannot explain the 31% of the real efficiency of

formal labor on average. As it can be seen from Table 1, the difference shrinks in years. This pattern coincides with the decrease in the informality size in years.

Table 1. Percent Difference in Formal TFP

Year	Mean	Std dev	Frequency
2002	.369	.306	44
2003	.339	.296	48
2004	.315	.279	48
2005	.301	.272	47
2006	.250	.255	52
Total	.313	.282	239

When the countries are categorized according to their income level, the differences in formal TFP are contrasting which can be seen in Table 2. The unexplained part of the formal TFP is significantly higher in low-income countries which is one of the important results. This means formal part of the productivity of low-income countries are higher than they seem if the informality is taken into consideration. As in one sector TFP estimations low-income (less productive) countries, TFP levels are more underestimated than high-income (productive) countries, it can be said that productivity differences in the formal part of the economy among countries are less than the general thought in the literature. When logarithm of TFP level in one sector and logarithm of formal labor TFP level in Model 1 are compared the standard deviation of former is 0.97 where the latter is 0.86 for 52 countries in 2006. Thus, it can be said that one of the reasons for income differences among countries is not that some countries do not have productive sectors in their economy, but having a big share of an unproductive informal sector.

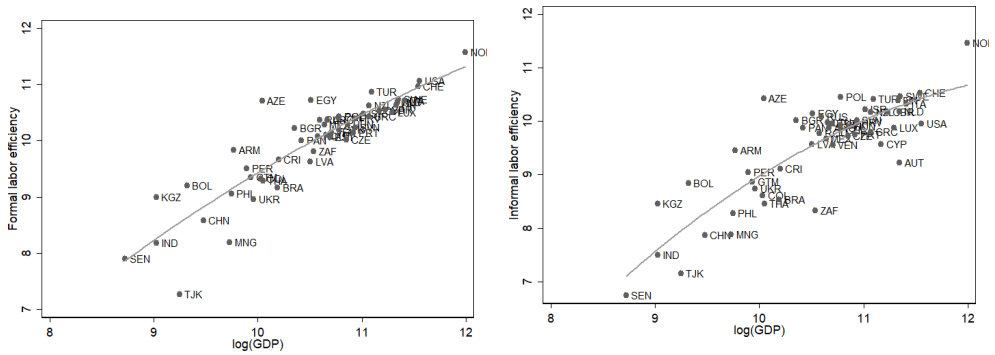
The results of different substitution values with formal and informal labor can be seen in the Figure A1, Figure A2, Figure A3 and Figure A4 (Appendix A) and Table B1

Table 2. Percent Difference in Formal TFP Grouped by Income Level

Year	2002	2003	2004	2005	2006
Low-income	.557	.546	.505	.497	.471
High-income	.098	.094	.091	.098	.111

and Table B2 (Appendix B). When substitution between different labors become more available, two sector model yields higher formal labor productivity levels.

In line with the literature, there is a positive relationship between formal labor efficiency and GDP per capita, as it can be seen in Figure 1. It is not surprising to find that when a country efficiently utilizes its formal labor, its income level boost. Norway stands out among other countries with its efficiency and income level. Although there is again a positive relationship between informal labor efficiency and income level, it is not a significant determinant of income level as formal labor efficiency. The relation between A^I and income gets weaker when income level increases.



(a) Formal Labor

(b) Informal Labor

Figure 1. GDP per worker level vs. efficiency level of labor

As is readily seen from Figure 2, formal labor efficiency and informal labor efficiency go hand in hand. It is not surprising as informal labor most of the times

include some unregistered part of the workers do same jobs with the other registered workers. Hence although their efficiency level is less than formal one for various reasons, the overall know-how in the country affect both formal and informal labor same which result in the same behavior in efficiency levels with income. However, it is important to remember that efficiency of formal and informal labor is affected by the relative wages. As in developed economies, excluding the US, the wage distribution is more egalitarian than the other countries, this may also affect the results.

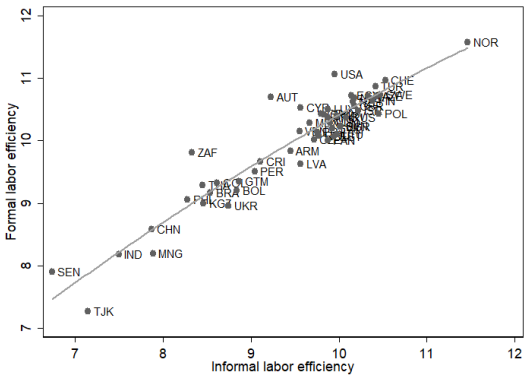


Figure 2. Efficiency level of formal labor vs. informal labor

One of the interesting questions is that how productivity ratios of two types of labor changes with the income level of the countries. If one country starts to use one of its labor more efficiently when it grows, it is said that there is a biased technology change. If it uses formal labor more efficiently than informal labor then it is formal-biased technology change and if it uses informal labor more efficiently than formal labor then it is informal-biased technology change. When we plot the efficiency ratios with income level in Figure 3, we see that it is almost a flat line. Thus, when a country upgrade its technology both formal and informal labor can utilize the new technology with the same rate of efficiency.

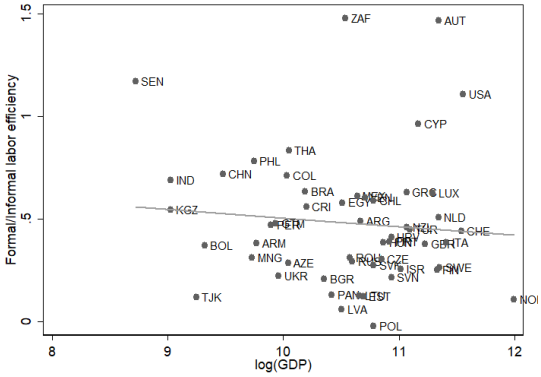


Figure 3. Formal/informal TFP ratios vs. GDP per-capita

As it is mentioned before, in the model countries choose their production technology according to their formal and informal labor endowments. The technology frontier of each country represents the possible choices for production technology. Figure 4 shows technology frontiers of US, Turkey, and Mexico as an example. The countries having relatively more informal labor choose an efficiency bundle that utilizes informal labor more. Hence, they are placed in the part of their frontier that is near x-axis. As it can be seen countries with less income such as Mexico has a frontier that is inside of the frontiers of richer countries such as Switzerland, Norway, and the USA. This shows the efficiency boundary on income levels of the countries. In section 1.4.3, how those boundaries affect the income dispersions among countries is investigated with a counterfactual analysis. The outer frontiers have higher B levels which can be seen as the overall efficiency of a country. Norway has the outermost frontier, thus it represents the world technology frontier.

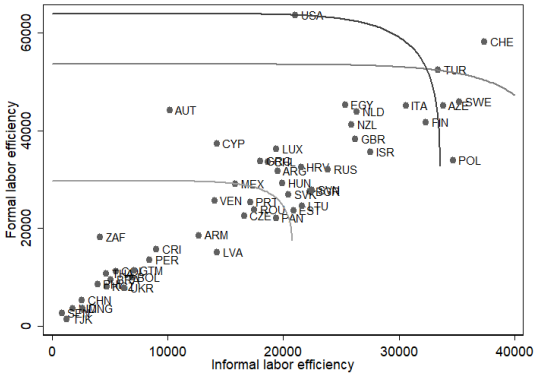
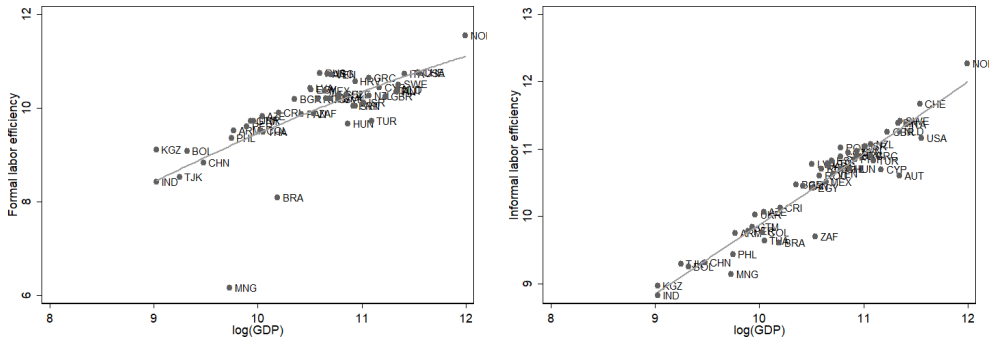


Figure 4. Technology frontiers of USA, TUR, and MEX

1.4.2. Model 2

In this model, there is a substitutability in both between formal labor and informal labor and also between capital and formal labor. One of the noteworthy results that differ from the one level CES model is the relationship between formal labor efficiency and income level. Although there is still a positive correlation between them it is not as significant as in the Model 1. This may result from that in Model 1 efficiency of capital is explained by the efficiency of formal labor as they are the substitute to each other to some extent. However as there is no substitution between informal labor and capital, results of informal labor efficiency are not affected by the change in the model construction.

Adding capital-formal labor complementarity into the model changes the relationship between the efficiency of formal and informal labor. Although it does not change the direction of the relationship, we have a humped pattern in this case where it is linear in Model 1. When we examine the Figure 5, we can see that formal efficiency of countries converges to each other when income level increases. Thus the differences among formal TFP in Model 1 can be attributed to capital efficiency, which means income differences between rich countries depend on how they utilize



(a) Formal Labor (b) Informal Labor

Figure 5. GDP per worker level vs. efficiency level of labor

their capital more than their formal labor. The relationship between efficiency level of formal and informal labor does not change significantly as it can be seen in Figure 6.

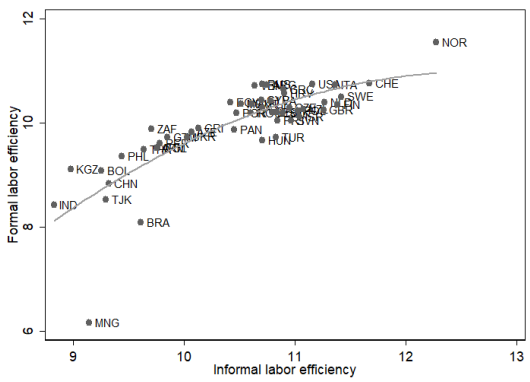


Figure 6. Efficiency level of formal labor vs. informal labor

The most striking difference between the results of two models is that adding capital-formal labor complementarity to model changes the biasedness of the technology change. As it can be seen in Figure 7, when a country increases its technology level, the informal labor utilizes the new technology better than the formal one.

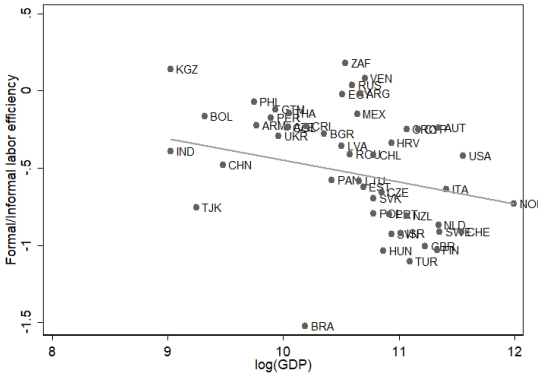


Figure 7. Formal/informal TFP ratios vs. GDP per-capita

In this model, technology frontiers become more curved compared to first model, as it can be seen in Figure 8. Incorporating the capital as a substitute effects the substitutability relationship of formal and informal labor.

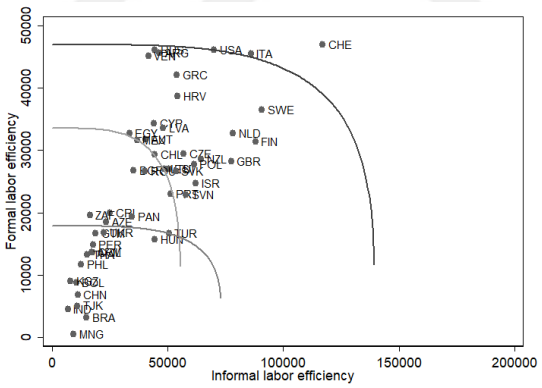


Figure 8. Technology frontiers of USA, TUR, and MEX

1.4.3 Counterfactual analysis

One of the aims of this paper is to see how the boundaries of technology affect the productivity, so the income level, of the countries. Hence a counterfactual analysis is conducted to find the income gain of removal of the barriers. By having each countries frontiers, world technology frontier can be identified as the outermost

frontier at hand. The technology frontier of Norway specifies the world technology frontier in all cases and all years. It is assumed that all countries can have access to the world technology frontier, thus they can choose the most appropriate technology pair from that production frontier to maximize their output levels. If all countries reached the outermost frontier and chose efficiency pair from this frontier, it is obvious that income levels of all countries, except the one whose frontier is the outermost one, would increase. The gain from removing the barriers are higher when barriers are more restrictive for a country. Figure 9 shows the gain that results from removing the barriers on technology. As it can be seen from the graph, the income level of a low-income country like Tajikistan can augment its output by almost nine-fold.

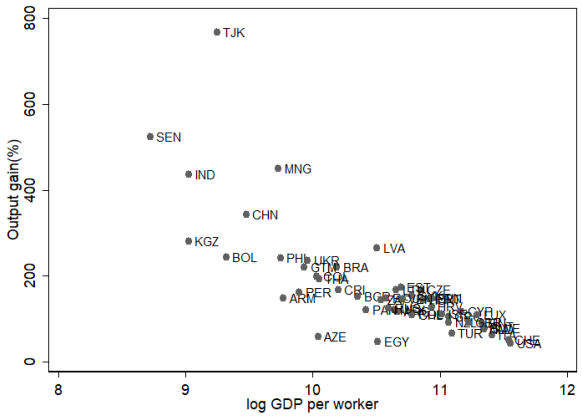


Figure 9. Output gain from reaching outermost frontier

By calculating the gain, it is aimed to figure out how much of the income differences among countries are resulting from the efficiency barriers. In the data standard deviation of the log of GDP per capita is 0.73, which indicates the income discrepancies among countries. Removing the efficiency barriers this number declines to 0.45. Thus, 38% of the income differences among countries results from the efficiency disparity while the other 62% results from endowment differences.

1.5 Conclusion

Understanding the underlying reasons for income differences among countries is one of the most crucial efforts in growth literature. This paper investigates two overlooked factors in the literature. First one is that TFP calculations are based on the formal economy, while most of the developing economies include a considerable size of informality. As the efficiency of formal and informal labor differ significantly, separating those two will give more accurate measures on real productivity levels of countries. The results show that incorporating this fact changes TFP calculations of formal sector nearly by 25% in 2006. Thus, ignoring the informality results in an underestimation of productivity levels. It is seen that both formal and informal labor productivity increases jointly with the income level of the country. This outcome may result from the fact that higher productivity of formal labor may trigger an increase in productivity of informal labor especially the ones that are in the same workplace.

The other factor which changes the understanding of technology differences among countries is appropriate technologies. Most of the growth literature stand on the belief that if the technology owned by high-income countries can be achieved by low-income countries, the efficiency level of low-income countries will increase. However, a production technology can be efficiently used only if it is appropriate to be used with that particular country's endowment. Thus it is suggested in this paper that countries choose their technology level on a feasible technology set conforming to their endowment level and those sets are the main determinant for income differences among countries. When technology frontiers are obtained by using productivity of formal and informal labor, it is seen that countries with higher income are located in the outer part of the frontiers of countries with lower income. When a

counterfactual analysis is practiced, it is found that by abolishing the barriers to efficiency, income differences can be decreased by 38%.

The main results are independent of the production technology used in the model. Findings from both one-level and two-level CES production function behave similarly. The main difference is that as there is a substitutability between formal labor and capital in Model 2 relationship between formal labor efficiency and income is less significant. The reason of that may be that formal labor efficiency in Model 1 also includes some part of capital efficiency. When those are separated the part that explained by formal labor efficiency shrinks.

Although this research gives plausible explanations about TFP differences, there is room for improvement for future research. First, data constraints bound the analysis for only 52 countries. By using broader data, one can obtain the regional frontiers to see the spatial aspects of efficiency barriers as well. Second, in this research, technology frontiers are investigated for a cross-section of countries for specific years. However, the evolution of the frontiers in time can also be informative about the income differences among countries and how they evolve in time. Next step will be adding a time dimension to analysis and investigate changes in technology frontiers of countries. It will be informative to see whether frontiers are converging to each other or not.

CHAPTER 2

MARGINAL COST OF PUBLIC FUNDS UNDER THE PRESENCE OF INFORMALITY

2.1 Introduction

Raising tax revenue in order to finance government spending generally has distortionary consequences for the economy, unless financed exclusively by lump-sum taxes or lump-sum tax equivalents.[1] For instance, taxes on earnings typically distort labor supply choice of workers, and taxes on capital income gains disincentivize physical capital investment motivation of capital owners. Assuming the economy functions on the "correct side" of the Laffer curve, i.e. raising taxes does not actually result in less revenue collection, the concept of marginal cost of public funds (MCF) formalizes the measurement of economic distortion due to increasing taxes by calculating the loss incurred by the society in raising one dollar revenue in order to finance government expenditure.

The trade-off behind MCF is a well-known, fundamental and yet a crucial one, rooting all the way back to the analyses by Pigou (1947), later being enriched by Stiglitz and Dasgupta (1974), Diamond and Mirrlees (1971) and Atkinson and Stern (1974), among others. While the first attempt to formalize the measurement of MCF dates back to Browning (1976), the idea of applying the MCF concept to different environments with different priorities have started both empirical and theoretical and computational line of literature in public economics soon after Browning (1976). Dahlby (1998) presents a calculation method for MCF and examines the social costs of a progressive taxation system which affects the supply decision in the labor market.

[1] A proportional consumption tax on consumption good that is demanded inelastically can de facto serve as lump-sum tax, hence considered as a lump-sum tax equivalent.

Sandmo (1998) claims that calculation of MCF under the representative-agent settings misses the redistributive role of taxation, thus he investigates MCF with heterogeneous households. Kleven and Kreiner (2006) study the labor force participation decision in an environment with fixed work cost and its effects on government revenue in an MCF context. They show that non-convexities created by fixed work cost have revenue effects which result in a higher marginal cost of funds. Hashimzade and Myles (2012) investigate MCF in a standard neoclassical growth model with a dynamic environment instead of a static one to compare capital and labor taxes.

Informality is an important fact that should be considered in taxation especially in developing countries where degree of informality is well above the world average. When a country lacks strong enough institutions for firms having to operate formally, taxation may drive some firms to informality. Thus, measuring the cost of taxation should be handled differently especially in countries with high rate of informal sectors. Although not taking informality into account in the measurement of the cost of taxation can be misleading, there is not much literature about the cost of taxation in a setting with informality. Auriol and Warlters (2012) investigate the MCF in the presence of informality with cross-country analysis. They calculate MCF values of different taxes for several African countries in a basic static set-up. Their main result suggests that when informal sector is large, the cost of taxation is high. Thus, it is possible to decrease MCF by increasing the tax base by including informal sector.

In this paper, we study MCF in the presence of informality within a dynamic general equilibrium framework. Studying MCF in a rich set-up with the informal sector is critical, because analyses lacking informality have economy-wide incorrect predictions, thereby reducing the quality of both policy recommendations and

conclusions derived from economic theory. Ignoring the dynamic aspects is also undesirable, as the behavior of capital accumulation is critical for macroeconomic success and well-being, and static models fall short in addressing these key aspects of the economy.

Our agenda in this paper is two-fold: first, we evaluate the effects of different types of taxes, in particular, capital and labor income, and consumption taxes, in a dynamic general equilibrium setting with an informal sector. We report the impacts of different taxes for the comparability of the costs of financing. For this goal, we use the simulations of the model to evaluate how the MCF is associated with different levels of informality rates. Then, using the data on taxes of several countries on the empirical level, we calibrate and measure MCF for a panel of developed and developing countries.

Our results show that in this setting, capital income tax is the most distortionary one, as in the spirit of the Chamley-Judd result, and the consumption tax the most costless one. We also show that the marginal cost of funds of both capital and labor income taxes increase with informality level in the country, which is in line with the findings of Auriol and Warlters (2012). However, consumption tax displays opposite behavior and the marginal cost decreases when informality increase in a country. There are also some regional differences.[2] Overlooking informality in the models that calculate MCF induces significant measurement errors. There are two main results we found especially striking related to that. First, using a model that ignores the informal sector results in an underestimation of MCF in capital income tax and an

[2]Western and Northern Europe and North America have less distortionary capital income tax than other taxes when we compare the rankings. This can result from the lower levels of informality in those regions.

overestimation in consumption tax. Underestimation of MCF in capital tax means being on the wrong side of the Laffer curve in the most of the countries. Thus, ignoring informality may lead to have taxing policies that are not optimal. The second interesting result is that the relationship between informality and the MCF of the labor income tax changes direction when we add informal sector in the model, which mainly results from the labor-leisure choice mechanism and the relationship between income and the tax rates of the country. Countries having smaller share of informality in their economy are the ones with high income, and high-income countries tax labor income more heavily than low-income countries. Thus, when informality is exogenous in the model, higher taxes result in higher distortion through labor-leisure choice and MCF levels rise. However, when we add informality into the model, the challenge in raising revenue due to informal sector overweigh the distortionary effects of high taxes and MCF levels increases with informality size. Thus, neglecting the informality may cause inaccurate interpretation of the cross-country differences in MCF.

2.2 Model

In this section, we describe the two-sector dynamic general equilibrium model that we use in our analysis, which is borrowed from Ihrig and Moe (2004) to a great extent.

The infinitely-lived representative household is endowed with K_0 units of initial productive physical capital and a total of $\mathcal{T} > 0$ units of time each period. The agent chooses how much time to allocate to leisure, as well as the formal and informal employment. The formal sector, denoted by the subscript F, has a standard Cobb-Douglas production technology and is subject to full taxation. The informal sector, denoted by the subscript I, however, uses only labor as an input. It is plausible

to assume that the informal sector is more labor-intensive compared to the formal sector.[3] Furthermore, the informal sector is subject to taxation only when it is caught by the monitoring authorities. Accordingly, we introduce a tax enforcement parameter ρ, which captures the frequency of being caught, thereby resulting de facto tax payments at the same rate. We assume that the tax revenue collected by the government is resulting in wasteful spending, or in other words spent for unproductive activities.

Formally, the problem by the representative household is as follows:

$$\begin{aligned} \max_{\{C_t, K_{t+1}, L_t, N_{It}, N_{Ft}\}_{t=0}^{\infty}} \quad & \sum_{t=0}^{\infty} \beta^t U(C_t, L_t) \\ \text{subject to} \quad & (1+\tau_c)C_t + K_{t+1} - (1-\delta)K_t = (1-\tau_k)r_t K_t + \\ & (1-\tau_n)w_{Ft}N_{Ft} + (1-\rho\tau_i)(w_{It}N_{It} + \pi_{It}) \\ & N_{It} + N_{Ft} + L_t = \mathcal{T} \end{aligned}$$

We assume that each period, our representative firm operates a constant - returns - to - scale (CRS) technology in the formal sector and and a decreasing-returns-to-scale (DRS) technology in the informal sector represented by the following production functions, respectively:

$$Y_{Ft} = \theta_{F_t} K_t^{\alpha} N_{Ft}^{1-\alpha}$$

$$Y_{It} = \theta_{I_t} N_{It}^{\gamma}$$

As before, the firm's optimization problem simplifies to a period-by-period profit maximization problem. If we assume that the firm is a price-taker, then for each

[3] A a possible interpretation of this assumption might be that the informal sector has a fixed amount of productive capital and cannot possibly accumulate physical capital. (Ihrig and Moe, 2004).

$t = 0, 1, \ldots, T$, the firm solves the following profit maximization problems:

$$\begin{aligned} \max_{K_t, N_{Ft}} \quad & \pi_{Ft} = Y_{Ft} - r_t K_t - w_{Ft} N_{Ft} \\ \text{subject to} \quad & K_t \geq 0, \ N_{Ft} \geq 0. \end{aligned}$$

and

$$\begin{aligned} \max_{N_{It}} \quad & \pi_{It} = Y_{It} - w_{It} N_{It} \\ \text{subject to} \quad & N_{It} \geq 0. \end{aligned}$$

Simple optimization procedures give the first-order conditions that solve the profit maximization problems; as before, the marginal products should equal their price for each $t = 0, 1, \ldots, T$:

$$\frac{\partial Y_{Ft}}{\partial K_t} - r_t = 0$$

$$\frac{\partial Y_{Ft}}{\partial N_{Ft}} - w_{Ft} = 0$$

$$\frac{\partial Y_{It}}{\partial N_{It}} - w_{It} = 0$$

The CRS technology for the formal sector implies $\pi_{Ft} = 0$, whereas the DRS technology in the informal sector leads to positive profits in this sector, i.e. $\pi_{It} = (1 - \gamma)\theta_{I_t} N_{It}^{\gamma} > 0$. Now we proceed to characterize the competitive equilibrium (CE) below.

Definition: Given the government policy variables $\{\tau_c, \tau_i, \tau_k, \tau_n, \rho\}$, a competitive equilibrium of this two-sector model is a set of sequences of allocations $\{C_t, , L_t, K_{t+1}, N_{It}, N_{Ft}\}_{t=0}^{\infty}$ and prices $\{w_{Ft}, w_{It}, r_t\}_{t=0}^{\infty}$ such that

1. Given the prices and policy $\{C_t, L_t, K_{t+1}, N_{It}, N_{Ft}\}_{t=0}^{\infty}$ maximizes representative agent's life-time utility.

2. Given the prices $\{N_{It}, N_{Ft}, K_t\}_{t=0}^{\infty}$ solve the profit maximization problems

3. All markets clear.

4. Government budget constraint is given by
   $R = \tau_c C + \tau_k \alpha Y_f + \tau_n (1-\alpha) Y_f + \rho \tau Y_i$

Assuming logarithmic utility (i.e. $U(C_t, L_t) = log(C_t) + \phi log(L_t)$), the maximization problem of the household yields the following Euler equation:

$$\frac{C_{t+1}}{C_t} = \beta[(1-\tau_k)\theta_F \alpha K_{t+1}^{\alpha-1} N_{Ft+1}^{1-\alpha} + 1 - \delta]$$

Since at equilibrium marginal products of two sectors must be equal, we have:

$$(1-\tau_n)\theta_F(1-\alpha)K_t^{\alpha} N_{Ft}^{-\alpha} = (1-\rho\tau)\theta_I \gamma N_{It}^{\gamma-1}$$

By rearranging the Euler equation, one can obtain K_t in terms of N_{Ft}:

$$K_{t+1} = N_{Ft+1}\left[\frac{(1-\tau_k)\theta_F \alpha}{(1+g_c)/\beta - 1 + \delta}\right]^{\frac{1}{1-\alpha}}.$$

Moreover, the time spent on informal labor can be obtained now using MP equality:

$$N_{It+1} = \left\{\frac{(1-\rho\tau)\gamma\theta_I}{(1-\tau_n)(1-\alpha)\theta_F}\left[\frac{(1+g_c)/\beta - 1 + \delta}{\alpha(1-\tau_k)\theta_F}\right]^{\frac{\alpha}{1-\alpha}}\right\}^{\frac{1}{1-\gamma}}$$

So at the steady state (i.e. when $g_c = 0$), the informal and formal labor become:

$$N_I = \left\{ \frac{(1-\rho\tau)\gamma\theta_I}{(1-\tau_n)(1-\alpha)\theta_F} \left[\frac{1/\beta - 1 + \delta}{\alpha(1-\tau_k)\theta_F} \right]^{\frac{\alpha}{1-\alpha}} \right\}^{\frac{1}{1-\gamma}}$$

$$N_F = \frac{(T - N_I)\gamma(1-\rho\tau)\theta_I N_I^{\gamma-1} - \phi(1-\rho\tau)\theta_I N_I^{\gamma}}{\gamma(1-\rho\tau)\theta_I N_I^{\gamma-1} + \phi[(\alpha(1-\tau_k) + (1-\alpha)(1-\tau_n))\theta_F (X)^{\frac{\alpha}{1-\alpha}} - \delta(X)^{\frac{1}{1-\alpha}}]}$$

where

$$X = \frac{\alpha(1-\tau)\theta_F}{1/\beta - 1 + \delta}$$

Once we have the steady-state expressions for N_I and N_F, we can obtain

$$K = N_F \left[\frac{(1-\tau_k)\theta_F \alpha}{1/\beta - 1 + \delta} \right]^{\frac{1}{1-\alpha}}$$

$$(1+\tau_c)C = (1-\tau_k)\alpha Y_F + (1-\tau_n)(1-\alpha)Y_F + (1-\rho\tau)Y_i - \delta K$$

$$R = \tau_c C + \tau_k \alpha Y_f + \tau_n (1-\alpha) Y_f + \rho\tau Y_i$$

Finally we can define the marginal cost of public funds for three different taxes as follows:

$$MCF_{\tau_k} = -\frac{\partial U/\partial \tau_k}{\partial R/\partial \tau_k}$$

$$MCF_{\tau_c} = -\frac{\partial U/\partial \tau_c}{\partial R/\partial \tau_c}$$

$$MCF_{\tau_n} = -\frac{\partial U/\partial \tau_n}{\partial R/\partial \tau_n}$$

The marginal cost of public funds shows the trade-off between the welfare loss and the revenue gain from the increase in taxes. It is higher when the marginal loss in the welfare is more than the additional revenue gain of the government.[4]

2.3 Data and calibration

The data that we use in our calculations and the calibrations of our parameters are from 1950 to 2010 and it covers 45 countries across different regions. We calculate marginal tax rates following Conesa et al. (2007). For capital share parameter α and depreciation rate parameter δ, we rely on the Penn World Table 9.0. We calculate the parameter β for each country separately by using Euler equation. We obtain the parameter estimate for leisure by using intratemporal condition on consumption and leisure. For formal output levels of countries, we use the estimates from Penn World Table 9.0 and we obtain estimates of informal output and the ratio of informal/formal labor from Elgin and Oztunali (2012).

Productivity parameters in the production functions θ_F and θ_I, and labor share parameter in the informal sector γ are free parameters that are not explicitly fed to the model. Instead, we calibrate them to match desired values of specific variables in the model. As the informality level in the economy is the vital concern in this framework, formal and informal output levels and the ratio of informal/formal labor are the ones matched exactly with the data by using θ_F, θ_I and γ. In the case of calculations of the model without informality, we use only θ_F and we match with formal output level.

In the simulation part, we calibrate the parameters in a way that desired values are matched with the averages of the countries used in the cross-country analysis. In

[4]Also it is possible for government to obtain less revenue by increasing tax. If this is the case, then MCF can also be negative.

order to get different informality levels, we use ρ (tax enforcement on informal sector) parameter.[5] In order to see if the results are driven by informality level or enforcement level, we perform a robustness check by changing informality level with θ_I. Results are similar and can be seen in Figure C1 and Figure C2 (Appendix C).

2.4 Results

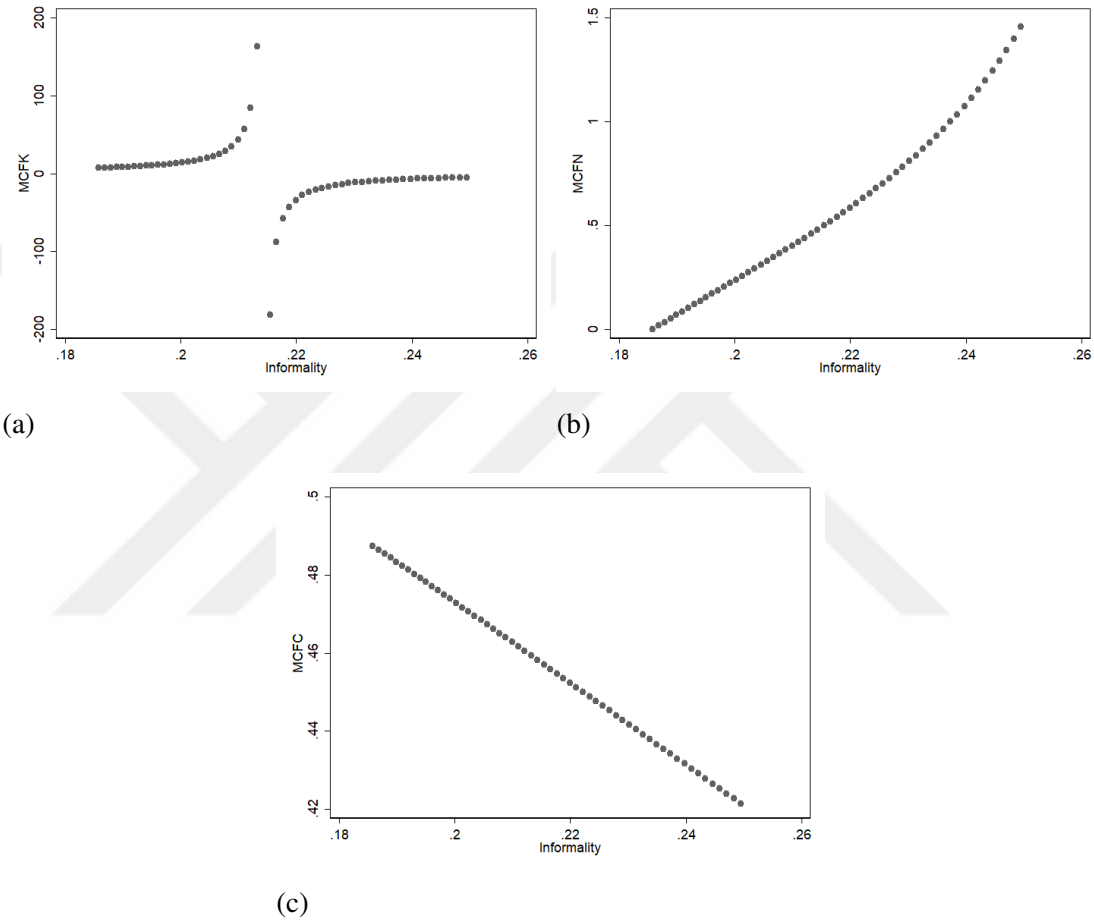
2.4.1 Simulation results

Before conducting a cross-country analysis, we first conduct a simulation experiment to elicit how the cost of different taxes reacts to informality level for a representative country. For the values that are fed into the model for the representative country, we use the average values of our sample and the parameters are calibrated in the same way that is explained above. Then we change the informality level by changing one of the free parameters ρ, which is the tax enforcement rate on the informal sector. We observe how the cost of raising revenue for the government for each tax responses to those changes.

As it can be seen from the Figure 10, cost of capital income tax increases with informality rate. After a certain point, the representative country passes to the left side of the Laffer curve. Thus, having a high level of informality obstructs government from increasing its tax revenues with higher tax rates. When the share of informality is getting higher, the utility of households starts to be affected less by the increase in capital income tax, as their capital level is smaller. However, raising the revenue with the same amount of increase in tax level becomes harder, as informal sector

[5]For the cross-country calibrations, we take ρ as zero.

constitutes a bigger part of the economy. Thus, the behavior of the cost is mostly determined by the revenue part, denominator, of the MCF.



(a) (b)

(c)

Figure 10. Simulation results for MCF and informality

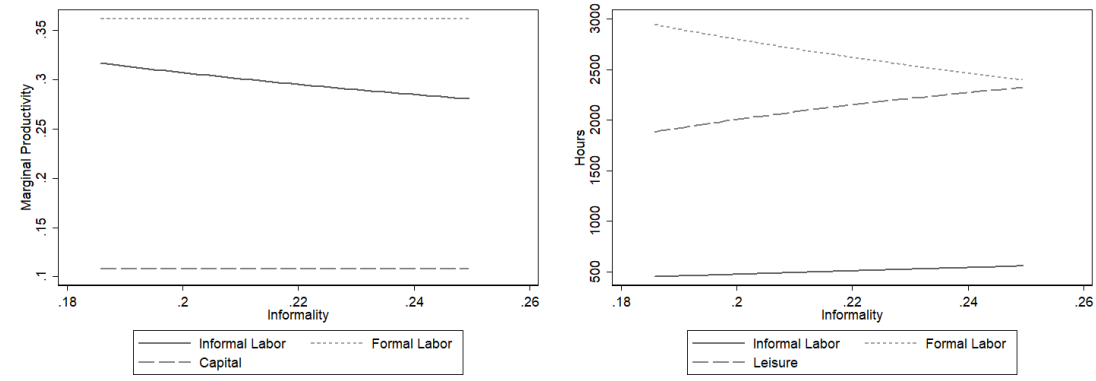
The marginal cost of labor income tax behaves similarly to that of capital income tax: It also increases with the informality rate. However, the driving forces behind this pattern that determines the shape of the cost graph are not the same as capital income tax. Different from the previous case, the decline in the utility of households rises with the informality level. Although the tax rate on capital and labor

income is similar, the marginal cost of capital income tax surpasses the labor income tax across all informality levels.

In contrast to income taxes, cost of consumption tax reacts positively to an increase in informality level. The result is in line with panel-data findings.[6] When we compare the cost of consumption tax with other taxes, we see that it is the least costly one.

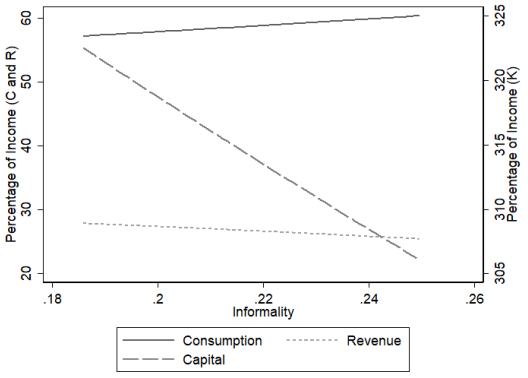
Simulation exercise delivers valuable lessons on several fronts. First, as informality rate changes via tax enforcement parameter in the simulation, it also shows the implications of different tax enforcement policies. Increasing auditing mechanisms on informal sector rise the revenue of the government as expected, but its marginal cost differs across types of tax. The increase in the number of firms that comply with tax obligations decreases the marginal cost of raising revenue in income taxes, which is consistent with the results of Auriol and Warlters (2012). However, it results in a rise in the marginal cost of consumption tax. In addition to that, we also look at the steady state values of some key steady-state variables in our simulation experiment to see how those variables are affected by tax enforcement, which can be seen in Figure 11. We found that the steady-state capital level becomes higher when informal sector size shrinks. However, the drawback of having a smaller informal sector is consuming less in the steady state, which results in a welfare loss in households. Another consequence of the decrease in the informality is that households start to work more to sustain their consumption level, which also has a negative impact on household utility.

[6]We discuss further on these in the next section



(a)

(b)



(c)

Figure 11. Steady-state values for different informality level

2.4.2 Cross-country analysis

In this section, we report and discuss model-based MCF measures for different taxes. As mentioned before, for the utility function, we use the standard logarithmic utility of the form $U(C_t, L_t) = log(C_t) + \phi log(L_t)$. Table 3 shows both MCF values and the rankings across all countries for each tax. As some of the MCF values are negative,

i.e. the country is on the left of the Laffer curve, we report also the rankings for the ease of comparison.[7]

We start our discussion with MCF for capital income tax and illustrate our findings in Figure 12a. The horizontal axes refer to the degree of informality of the country, while the vertical axis refers to the ranking of MCF of capital income tax across countries. The two ends of each line show the resulting ranking of a country with assuming no informality and also the result of the model with informality. For both assumptions, there is a positive relationship between informality rate and the cost of the capital income tax.[8] In countries with high informality size, one can easily start to operate informally which decreases the taxing pool of the government for raising the revenue and it leads to higher marginal costs of taxation on formal activity. Our result is also same as the simulation experiment. We also look at the effect of tax rate on MCF. We find that MCF of capital income tax increases with tax rate, a related figure can be found in Figure C3 (Appendix C).

When the values for MCF of capital income taxes are investigated, the first salient pattern is that it is the most costly tax among others in the most of the countries. Another pattern that can be incurred from the Table 3 is that when MCF of capital income tax is measured in a model with no informality, it generally underestimates the cost. Model with informality reveals that the real cost of taxation is higher and as can be understood from negative values most of the countries are on

[7]Rankings are assigned in a way that country having least costly taxation is ranked smaller than the others. Negative MCF values are treated as it is costlier than a positive one because being on the left of the Laffer curve means that increasing tax rates decreases both utilities of household and the revenue of the government which is a worse situation than decreasing only the utility. In the graphs, the rankings are used again for the sake of interpretation of the results easily.

[8]Having high cost in taxation means that for the same amount of revenue gain, more distortion is created in the economy.

Table 3. Summary of the Results

		With Informality						Without Informality					
Region	Country	MCFK	Rank	MCFC	Rank	MCFN	Rank	MCFK	Rank	MCFC	Rank	MCFN	Rank
East Asia & Pacific	Hong Kong	0.56	6	0.13	1	0.10	2	0.55	2	0.20	1	0.29	1
	Taiwan	-10.88	23	0.27	3	1.84	24	1.21	20	0.46	5	0.74	5
	Singapore	1.26	9	0.28	6	0.25	7	1.14	18	0.62	14	1.23	21
	Australia	-13.79	22	0.46	26	0.14	4	0.86	10	0.90	27	1.33	22
	New Zealand	4.76	18	0.51	32	0.38	13	1.36	24	0.91	28	1.51	28
	Japan	-0.31	41	0.56	36	0.22	6	1.38	26	1.06	36	1.57	29
	Korea	-8.14	24	0.32	9	-23.19	30	0.89	12	0.59	13	0.80	7
	Average	-3.79	20	0.36	16	-2.89	12	1.05	16	0.68	18	1.07	16
Eastern Europe	Bulgaria	4.06	17	0.28	5	1.91	26	0.97	14	0.39	3	0.61	4
	Poland	3.27	15	0.34	15	0.28	9	0.99	15	0.55	11	0.76	6
	Romania	-5.77	27	0.32	12	-9.48	31	1.45	28	0.53	9	0.97	13
	Hungary	2.52	13	0.42	22	0.37	12	0.89	11	0.71	19	1.08	16
	Czech Republic	2.53	14	0.36	17	0.53	20	1.22	21	0.73	20	1.35	25
	Average	1.32	17	0.35	14	-1.28	20	1.10	18	0.58	12	0.95	13
Latin America & Caribbean	Jamaica	-3.81	28	0.27	4	0.05	1	1.36	25	0.45	4	0.60	3
	Colombia	1.02	7	0.32	11	-1.39	35	0.78	8	0.64	15	0.81	8
	Peru	-0.53	29	0.29	7	-0.18	42	3.36	41	0.54	10	0.88	9
	Chile			0.33	14	2.21	27			0.46	6	0.91	10
	Brazil	-0.84	36	0.32	10	-1.11	36	2.57	39	0.59	12	0.92	11
	Trinidad and Tobago	-6.20	26	0.31	8	-8.74	32	2.09	35	0.52	8	1.05	15
	Mexico	-0.84	35	0.42	20	1.89	25	4.27	42	0.67	16	1.15	18
	Argentina	-2.02	29	0.43	23	-2.18	34	5.29	43	0.68	17	1.20	19
	Venezuela	-0.50	40	0.45	25	-0.55	37	2.94	40	1.45	40	4.22	40
	Barbados	-6.98	25	0.50	31			1.46	29	0.78	22		
	Average	-2.30	29	0.37	15	-1.11	30	2.68	34	0.68	15	1.30	15
Middle East	Israel	0.20	3	0.62	39	12.43	29	1.16	19	1.51	41	3.05	39
	Average	0.20	3	0.62	39	12.43	29	1.16	19	1.51	41	3.05	39
North America	United States	1.09	8	0.39	18	0.28	10	0.76	7	0.70	18	1.04	14
	Canada	1.54	10	0.42	21	0.32	11	0.69	5	0.82	24	1.22	20
	Average	1.32	9	0.40	20	0.30	11	0.72	6	0.76	21	1.13	17
Northern Europe	Iceland	-0.78	38	0.54	34	-0.29	40	0.70	6	1.04	33	1.62	31
	Norway	-1.51	31	0.56	35	0.97	23	1.00	16	1.29	37	2.35	36
	Denmark	-0.91	33	0.92	45	-0.41	39	1.50	31	2.11	44	7.27	42
	Sweden	-0.81	37	0.84	44	-0.54	38	2.26	38	2.20	45	10.67	43
	Finland	-0.22	42	0.80	43			1.09	17	1.87	42		
	Average	-0.85	36	0.73	40	-0.07	35	1.31	22	1.70	40	5.48	38
Southern Europe	Portugal	-0.85	34	0.48	29	-4.62	33	1.33	23	0.88	26	1.34	23
	Spain	-1.80	30	0.45	24	0.39	14	1.26	22	0.87	25	1.35	24
	Turkey	-1.37	32	0.41	19	-0.27	41	2.01	34	0.74	21	1.40	27
	Greece	0.01	1	0.49	30	2.30	28	2.13	36	0.97	30	1.84	33
	Cyprus	0.44	5	0.36	16	0.13	3	0.68	4	1.02	31	1.87	34
	Italy	-0.10	43	0.57	37	0.52	19	2.18	37	1.34	39	2.72	38
	Average	-0.61	24	0.46	26	-0.26	23	1.60	26	0.97	29	1.75	30
Western Europe	Switzerland	0.31	4	0.22	2	0.20	5	0.31	1	0.38	2	0.49	2
	Ireland	2.48	12	0.32	13	0.57	21	1.43	27	0.49	7	0.93	12
	France			0.47	28	0.41	15			0.81	23	1.09	17
	Germany	-26.47	21	0.46	27	0.43	16	0.80	9	0.91	29	1.36	26
	Netherlands	2.37	11	0.53	33	0.60	22	0.61	3	1.03	32	1.62	30
	Luxembourg	3.69	16	0.59	38	0.52	18	0.90	13	1.05	34	1.64	32
	United Kingdom	8.47	19	0.63	40	0.51	17	1.68	33	1.06	35	2.10	35
	Austria	20.12	20	0.75	41	-0.00	43	1.60	32	1.30	38	2.67	37
	Belgium	0.04	2	0.78	42	0.28	8	1.50	30	1.95	43	4.48	41
	Average	1.38	13	0.53	29	0.39	18	1.10	19	1.00	27	1.82	26

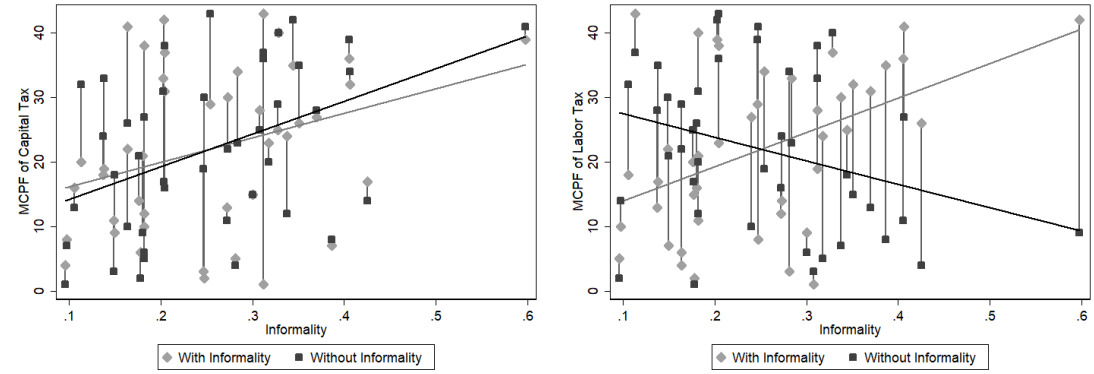
the wrong side of the Laffer curve. Although policymakers are most of the time trying to optimize the tax revenues before implementing a new tax plan, we see that existence of the informal sector shifts the optimal point. Thus, ignoring the informal sector in the economies when measuring their cost in taxation may result in drawing wrong conclusions.[9]

We concentrate on the nature of formal sector wage taxes next and display our results in Figure 12b. We notice that adding informal sector into the model changes the relationship between the cost and the informality size dramatically. While the cost increases with informality size in the model with informality, it decreases in the model with no informal sector. Thus, we cannot say that model with no informality overestimates or underestimates the MCF, the effect changes from country to country. The model with informality gives a positive link between informal sector size in the country and the MCF of labor income tax as expected. When formal sector size gets smaller, raising the same amount of revenue requires a higher increase in tax level, resulting in a higher distortion in the economy. However, the main determinant of the result of the model without informality is the relationship between labor income tax levels and the income level of the country.[10] Another fact from the literature is that high-income countries have smaller informal sector size. Thus, the countries having a big share of informality in their economy are also the ones that have lower labor income tax rates.[11]

[9]The different regions have different patterns on the cost of taxation. Western Europe and North America rank better in capital income tax as against other taxes. Northern Europe has the most costly capital income tax compared to others in the sample.

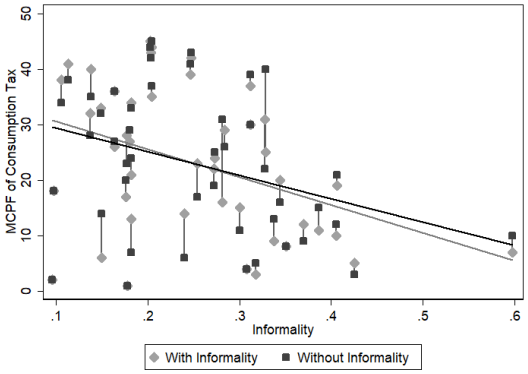
[10]In the sample, there is a significant positive correlation between those two indicators.

[11]Related graph can be found in Appendix. (Figure C4)



(a)

(b)



(c)

Figure 12. Rankings of MCF and informality

As a result, high tax levels make households to choose leisure over labor and create more distortions, meaning that increase in taxation resulting in a higher decrease in utility of the household. The summary of the labor income tax and the distortion level in terms of informality level can be found Table D1 and D2. Thus, the origin of the shape of the graph of informality and the cost of labor income tax in the model without informality is the distortionary nature of the labor income tax. In the

model with informality, the distortionary effect is not dominant, as there is also an informal labor option, one can choose over formal labor instead of leisure.[12]

Next, we focus on the MCF for consumption tax and report our findings in Figure 12c. As expected, consumption tax is the costless one among others. The relation between cost of the consumption tax and the informality shows a downward pattern, as we found in the simulation, which is mainly resulted from the increase in consumption percentage of income with the level of informality. As the cost of income taxes is high but consumption tax creates less distortion in countries with high informality, financing government expenditures with consumption tax in those countries may be more efficient.[13]

Regional differences are evident especially in Northern Europe. Those countries face huge costs of consumption tax relative to other countries. It is not surprising as they both have high consumption tax rates and a low level of informality in their economy. Although Latin America seems to have less costly labor income tax compared to other regions in the simple model both Latin America and Northern Europe perform badly in the model with informality. East Asia and Pacific countries have less costly labor income tax compared to other countries.

2.5 Conclusion

Keeping account of the distortions resulting from taxation is critical in the cost-benefit analysis of financing government spending and MCF is commonly used in literature to measure those distortions. Although most of the countries, especially the developing ones, contain a big share of informality in their economy, there is not

[12]We checked also if the MCF of the labor income tax rises with the particular tax rate or not, as expected it does, the related figure can be found in Appendix C. (Figure C3)

[13]However, the distributive aspects of taxation are not considered in this study.

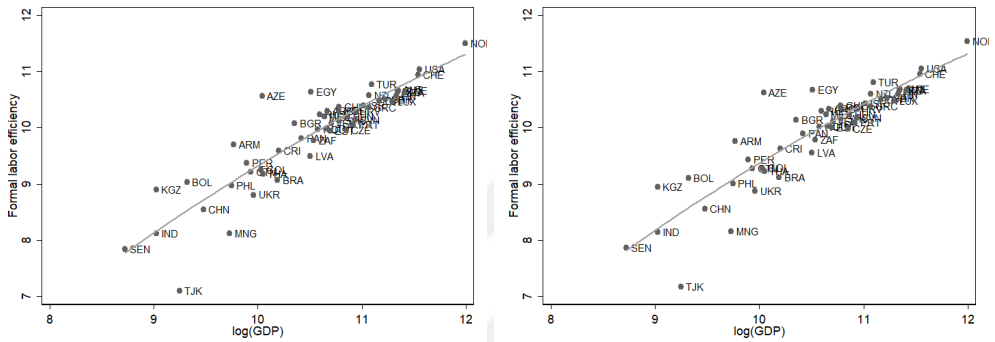
much weight put on this aspect in the literature about MCF. In this paper, we address that issue and take informality into consideration in modeling the economy. We use a two-sector model, formal and informal, in a dynamic general equilibrium framework. As each tax creates a different level of distortions in the economy, we aim in this paper to compare the marginal cost of capital and labor income and consumption tax which are commonly used in financing the government spending. First, a simulation exercise is done to see the effect of informality level on the cost of taxation. Then, by using panel data for 45 countries, the model is calibrated and MCF values are calculated for each country in our sample.

Our results show that capital income tax costs the most, while consumption tax costs the least. This result is very beneficial for the policy-making purposes. However, as the model is based on a representative agent framework, one should know that the model does not take the redistributive aspect of taxes into account. Both the results of simulation and the cross-country analysis show that informality level is positively related with MCF of income taxes and negatively related to MCF of consumption tax. Another important result shows how important to take informality into account when MCF is calculated. When model includes informal sector, our findings reveal that the marginal cost of capital income tax is higher than in the one-sector model. In addition, we report that most of the countries are on the left of the Laffer curve, meaning that tax structure that is implemented by overlooking the informal sector is not the optimal one. In the labor income tax, mismeasurement is more severe than the other taxes. If the cost of taxation is calculated without the presence of informal sector, countries with higher tax levels have a higher cost as taxes result in more distortion in the economy. However, having a large informal sector makes raising revenue harder which also increases the cost of taxation. Latter

one outweighs the former one in our model. Thus, the relationship between informality and cost of labor income tax changes direction by including the informal sector. When we study the consumption tax, unlike the capital income tax the one-sector model overestimates the MCF. Thus, measuring MCF with a one-sector model results in a severe mismeasurement in the cost calculations.

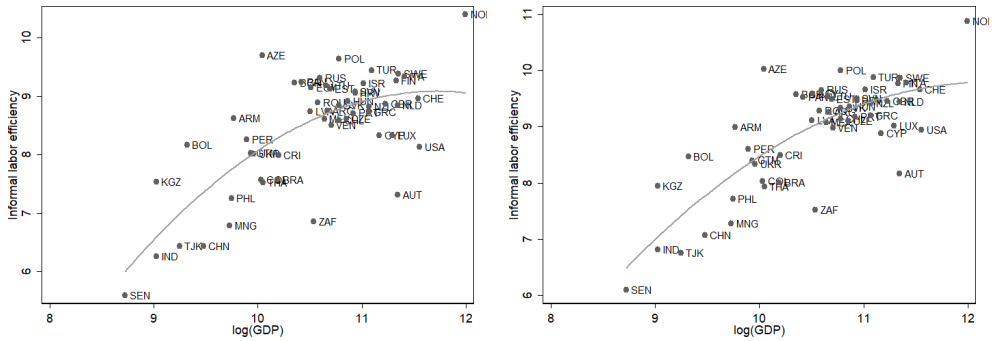
APPENDIX A

FIGURES RELATED TO CHAPTER 1



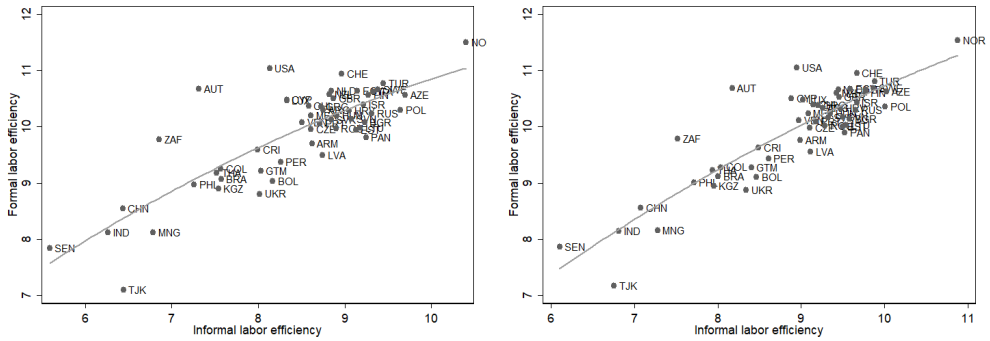
(a) σ=0.6 (b) σ=0.7

Figure A1. GDP per worker level vs. efficiency level of formal labor



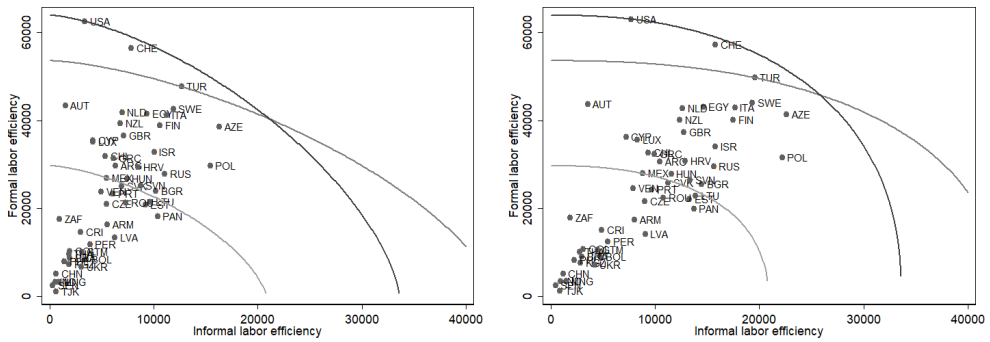
(a) σ=0.6 (b) σ=0.7

Figure A2. GDP per worker level vs. efficiency level of informal labor



(a) σ=0.6 (b) σ=0.7

Figure A3. Efficiency level of formal labor vs. informal labor



(a) σ=0.6 (b) σ=0.7

Figure A4. Technology frontiers of USA, TUR, and MEX

APPENDIX B

TABLES RELATED TO CHAPTER 1

Table B1. Percent Difference in Formal TFP when σ=0.6

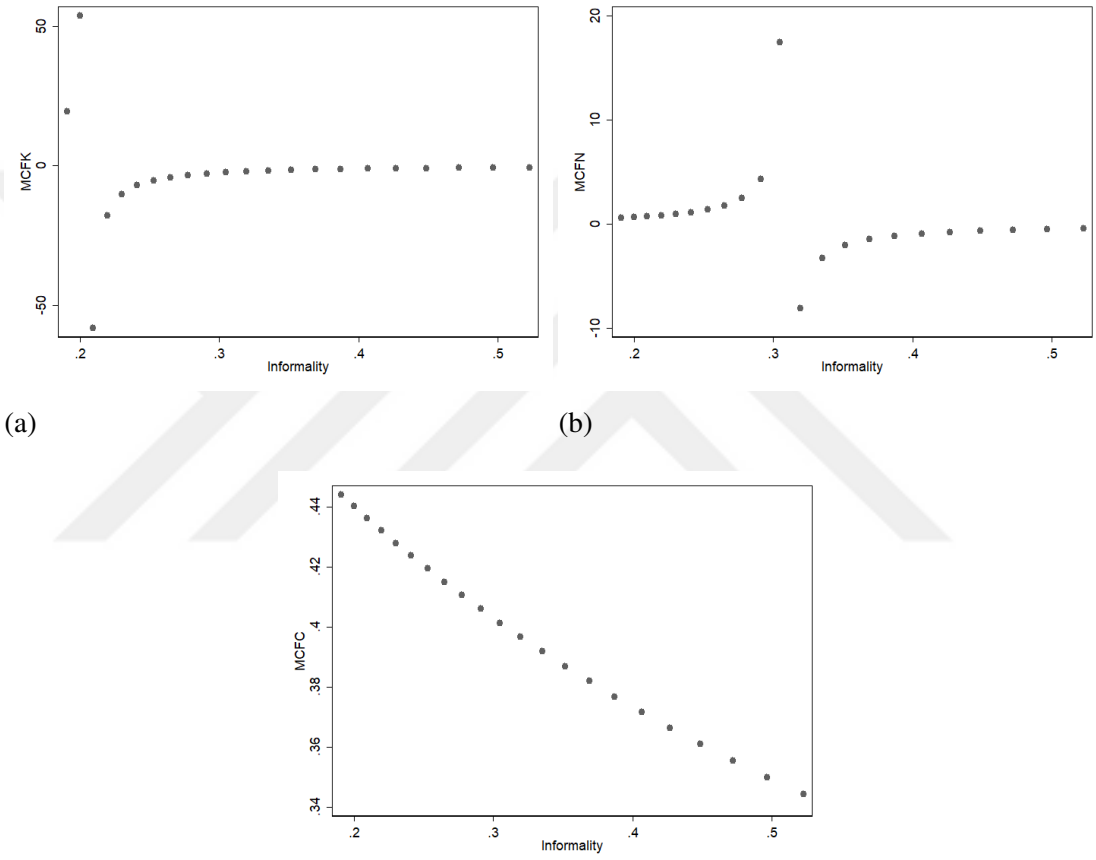
Year	Mean	Std. Dev.	Freq.
2002	0.256	0.254	44
2003	0.226	0.250	48
2004	0.205	0.234	48
2005	0.193	0.230	47
2006	0.140	0.218	52
Total	0.202	0.238	239

Table B2. Percent Difference in Formal TFP when σ=0.7

Year	Mean	Std. Dev.	Freq.
2002	0.305	0.276	44
2003	0.275	0.268	48
2004	0.253	0.252	48
2005	0.240	0.247	47
2006	0.188	0.233	52
Total	0.250	0.256	239

APPENDIX C

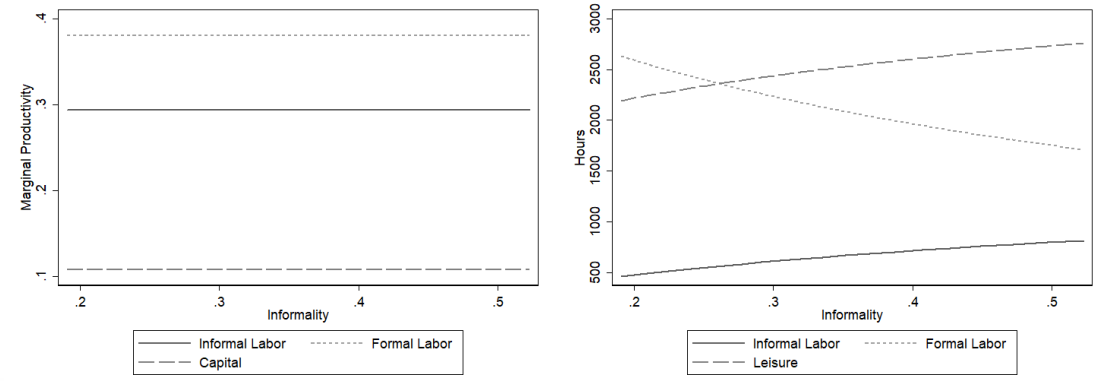
FIGURES RELATED TO CHAPTER 2



(a) (b)

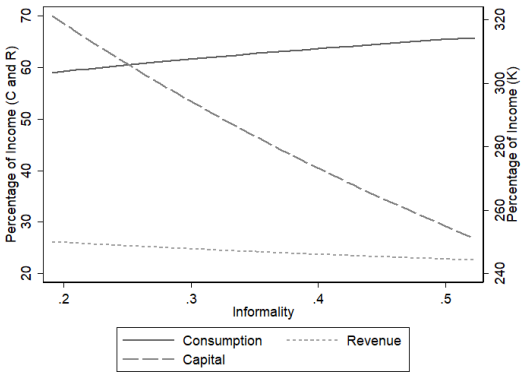
(c)

Figure C1. Simulation result for MCF and informality



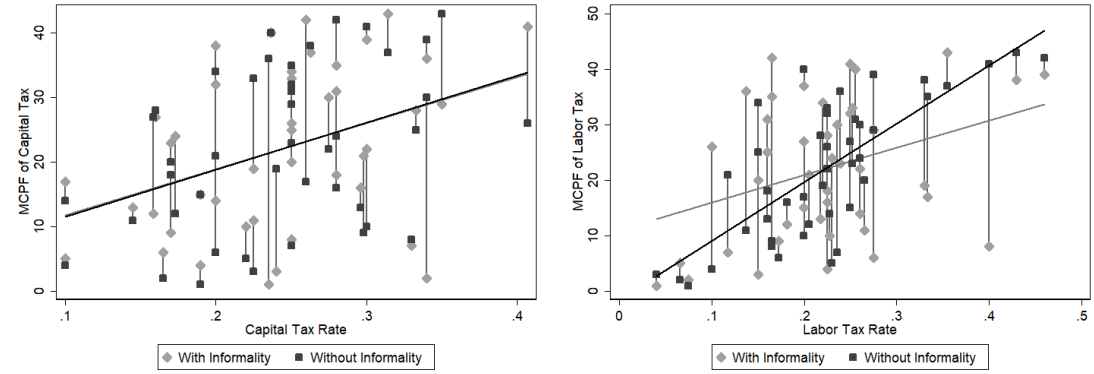
(a)

(b)



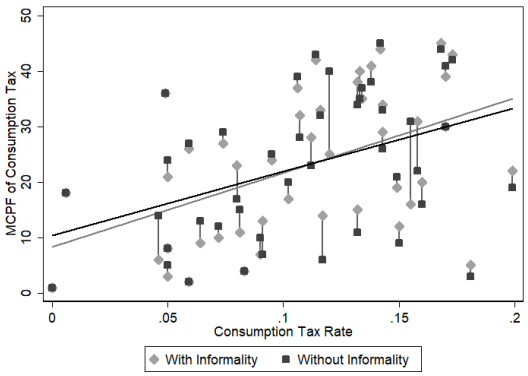
(c)

Figure C2. Steady-state values for different informality level



(a)

(b)



(c)

Figure C3. Rankings of MCF and tax rates

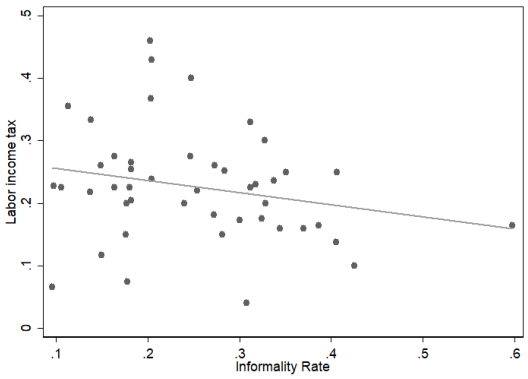


Figure C4. Labor income tax and informality rate of the countries in the sample

APPENDIX D

TABLES RELATED TO CHAPTER 2

Table D1. Summary of Labor Income Tax

Informality		Mean	Std. Dev.	Freq.
	<0.2	0.216	0.079	17
$0.2<$	<0.3	0.286	0.103	12
$0.3<$		0.194	0.071	17
	Total	0.226	0.089	46

Table D2. Summary of $\partial U/\partial \tau_n$

Informality		Mean	Std. Dev.	Freq.
	<0.2	-1.391	0.207	17
$0.2<$	<0.3	-1.569	0.401	12
$0.3<$		-1.169	0.210	17
	Total	-1.355	0.310	46

REFERENCES

Antras, P. (2004). Is the US aggregate production function Cobb-Douglas? New estimates of the elasticity of substitution. *Contributions to Macroeconomics*, 4(1), 1161.

Atesagaoglu, O. E., Elgin, C., & Oztunali, O. (2017). TFP growth in Turkey revisited: The effect of informal sector. *Central Bank Review*, 17 (1), 11-17.

Atkinson, A. B., and Stern, N. H. (1974). Pigou, taxation and public goods. *The Review of Economic Studies*, 119–128.

Auriol, E., & Warlters, M. (2012). The marginal cost of public funds and tax reform in Africa. *Journal of Development Economics,* 97(1), 58–72.

Bowles, S. (1970). Aggregation of labor inputs in the economics of growth and planning: experiments with a two-level CES function. *Journal of Political Economy*, 78(1), 68-81.

Browning, E. K. (1976). The marginal cost of public funds. *The Journal of Political Economy*, 84(2),283–298.

Busso, M., Fazio, M. V., & Algazi, S. L. (2012). (In) formal and (un) productive: the productivity costs of excessive informality in Mexico. *IDB Working Paper Series*, No. IDB-WP-341

Caselli, F & Coleman, W. J. II, (2002). The U.S. technology frontier. *American Economic Review P&P*, 92 (2), pp. 148-152.

Caselli, F & Coleman, W. J. II, (2006). The world technology frontier. *American Economic Review*, 96 (3), pp. 499-522.

Conesa, J. C., Kehoe, T. J., & Ruhl, K. J. (2007). Modeling great depressions: The depression in Finland in the 1990s. *National Bureau of Economic Research*,(No. w13591).

Dabla-Norris, E., Gradstein, M., & Inchauste, G. (2008). What causes firms to hide output? The determinants of informality. *Journal of Development Economics*, 85(1), 1-27.

Dahlby, B. (1998). Progressive taxation and the social marginal cost of public funds. *Journal of Public Economics,* 67(1), 105–122.

Dahlby, B. (2008). The marginal cost of public funds: Theory and applications. *MIT Press Books*, 1.

D'Erasmo, P. N., & Boedo, H. J. M. (2012). Financial structure, informality and development. *Journal of Monetary Economics*, 59(3), 286-302.

Diamond, P. A., & Mirrlees, J. A. (1971). Optimal taxation and public production I: Production efficiency. *The American Economic Review*, 8–27.

Elgin, C., & Oztunali, O. (2012). Shadow economies around the world: Model-based estimates. *Bogazici University Department of Economics Working Papers*, 5, 1-48.

Elgin, C., & Sezgin, B. (2017). Sectoral estimates of informality: A new method and an application to Turkish economy. (No. 2017/02). Bogazici University, Department of Economics.

Gatti, R., & Honorati, M. (2007). Informality among formal firms: firm-level, cross-country evidence on tax compliance and access to credit. *World Bank Publications*, (Vol. 6597) .

Gindling, T. H., Mossaad, N., & Newhouse, D. (2016). How large are earnings penalties for self-employed and informal wage workers? . *IZA Journal of Labor and Development*, 5(1), 20.

Hashimzade, N., & Myles, G. D. (2012). The marginal cost of public funds in growing economies. *Annals of Economics and Statistics*, (113/114), 11-36.

Ihrig, J., & Moe, K. S. (2004). Lurking in the shadows: the informal sector and government policy. *Journal of Development Economics,* 73(2), 541–557.

Klenow, P. J., & Rodrguez-Clare, A. (1997). The neoclassical revival in growth economics: Has it gone too far? *NBER Macroeconomics Annual*, 73-103.

Kleven, H. J., & Kreiner, C. T. (2006). The marginal cost of public funds: Hours of work versus labor force participation. *Journal of Public Economics,* 90(10), 1955–1973.

Leyva, G.,& Urrutia, C. (2018). Informality, labor regulation, and the business cycle. Unpublished manuscript.

Pigou, A, C. (1947). Economic progress in a stable environment. *Economica*, 180–188.

Prescott, E. C. (1998). Lawrence R. Klein lecture 1997: Needed: A theory of total factor productivity. *International Economic Review*, 525-551.

Porta, R. L., & Shleifer, A. (2008). The unofficial economy and economic development. *National Bureau of Economic Research*, (No. w14520).

Sandmo, A. (1998). Redistribution and the marginal cost of public funds. *Journal of Public Economics,* 70(3), 365–382.

Soto, H. D. (1989). *The other path: The invisible revolution in the Third World*, New York: Harper & Row Pulishers

Stiglitz, J. E., & Dasgupta, P. (1971). Differential taxation, public goods, and economic efficiency. *The Review of Economic Studies*, 151–174.

Ulyssea, G. (2014). Firms, informality, and development: Theory and evidence from Brazil. *American Economic Review*. (No.632)