TWO ESSAYS ON MACROECONOMICS

HASAN KADİR TOSUN

BOĞAZİÇİ UNIVERSITY

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ABSTRACT

Two Essays on Macroeconomics

This thesis is composed of two essays on macroeconomics. In the first essay, motivated by the empirical evidence that implies a negative correlation between government trust and the size of informal sector, we develop a game-theoretical model to account for this dynamic. We construct a model in which government type, which cannot be directly observed by households, follows a Markov chain; and households allocate their labor between formal and informal sector, each with different production technologies. We characterize the Markov perfect equilibrium of the model that implies that the size of informal sector is relatively higher for economies in which the level of government trust is lower.

In the second essay, we develop a model-based approach to create measures of different types of economic risks, namely fiscal risk, financial risk, and labor market risk, for a panel of countries. We use an annual cross-country dataset that includes fiscal policy variables, labor market variables, and financial variables to explain their effect on the variation in total productivity. Using the estimated TFP series, we run a DSGE model by calibrating model parameters to match several moments in the data so as to obtain measures for fiscal, financial and labor market risks. This exercise allows us to construct a model-based dataset of three categories of risks mentioned above, and to calculate the "true welfare costs" of different kinds of country-specific risks.

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CHAPTER 1
PUBLIC TRUST, FISCAL POLICY AND THE SIZE OF INFORMAL SECTOR

1.1 Introduction

The presence of large informal sector in the developing countries constitutes a barrier for growth for several reasons. First, the allocation of the significant portion of labor force to the less productive informal sector results in low aggregate productivity (Ihrig and Moe, 2004). Another reason is that a large informal sector implies lower government revenues and therefore, lower government capacity which results in lower levels of enforcement that would exacerbate the problem of informality. Additionally, an increase in the size of informal sector results in a decrease in the availability of public services, and therefore lessens productivity (Loayza, 1996).

Even though informality is a widespread phenomenon throughout the world (see Elgin and Öztunalı, 2012) and poses serious social, economic, cultural and political challenges, many issues about its nature and consequences still remain largely under-explored or unresolved. There are many open questions regarding the determinants and/or effects of informality. One recently cited determinant of informality is trust in an economy. With the construction of recent estimates on peoples' perceptions of the government, one recent factor that is associated with informality is public trust in the government. Even if governments introduce a policy to encourage households to work in the formal sector to alleviate the problem arising from the high levels of informality, some households might believe that the aim of the government is to capture the tax revenue, and the goal of the policy is to increase the tax base. Therefore, the effectiveness of the policy depends on households' level of trust to their government about the commitment to the announced policy.

In order to model the link between trust in the government and the size of shadow economy, a setting in which the government chooses whether to commit to or deviate from the announced policy and households decide on amount of labor supplied to formal and informal sectors under the presence of informational asymmetry about the true type of government in power can be designed as a game between these two. The models with several types of government exist in the literature to examine the issues such as taxation, debt repayment, as well as monetary growth. Among them, D'Erasmo (2008) examines the link between government reputation and debt repayment in several emerging economies. He characterizes a Bayesian Nash Equilibrium of the game between the government and the lender, and shows that lender's assessment of the government type is one of the main determinants of the terms of credit. Lu (2013) presents a model with two government types, which are not observable by the households and firms in the economy. They provide an optimal tax policy that a trustworthy government chooses in such an environment. Araujo and de Souza (2010) investigate workers' and firms' entry and exit decisions to formal and informal sectors and the effect of taxes by utilizing an evolutionary game theory approach.

Several empirical papers examine the relation between government quality and the size of informal sector as the level of trust in the government is directly linked to government quality. Dabla-Norris, Gradstein, and Inchauste

(2008), both theoretically and empirically, show that the quality of legal framework is significantly associated with the size of informal sector. Friedman, Johnson, Kaufmann, and Zoido-Lobaton (2000), by using data for 69 countries, show that informal activity is associated with corruption. Additionally, D'Hernoncourt and Méon (2012) report that both generalized trust and trust in institutions affect the size of shadow economy.

Figure 1 illustrates a strong negative correlation between the size of shadow economy and trust in several political and bureaucratic institutions.

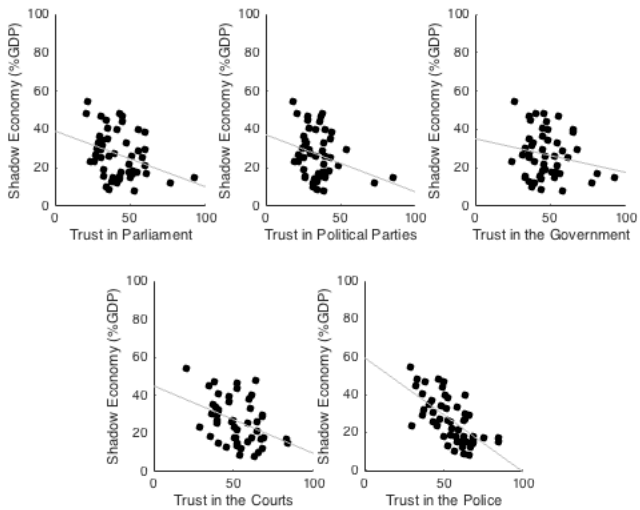

Figure 1. Shadow Economy vs Trust

Trust measures for 50 countries, including both developing and developed countries, are calculated by using the World Values Survey Wave 5 that covers the period 2005-2009. The participants are asked to report the level of confidence in the political parties, courts, the government, the police and the parliament in their countries. The data for the size of shadow economy (as % of GDP) are from Elgin and Öztunalı (2012).

The rest of the chapter is organized as follows. Section 2 describes the model. Section 3 characterizes the household optimization. Section 4 presents the Markov perfect equilibrium of the economy described. The main results of the chapter regarding the level and persistence of informality is presented in Section 5. Finally, Section 6 concludes.

1.2 Analytical framework

We consider an economy consisting of a continuum of households and a government. Assume that households are distributed uniformly over [0,1] interval. The government can be of two types, *trustworthy* or *opportunistic*, but the type of the government cannot be observed by the households. The households maximize utility, while the opportunistic government's goal is to maximize the tax revenue that it can use as office rent.

Trustworthy government does not tax output produced in either sector. Opportunistic government, on the other hand, can either commit to a zero-tax policy similar to the trustworthy government or deviate by taxing the formal output at a rate τ and the informal output at a rate $\phi\tau$, where $\phi < 1$ can be interpreted as the tax enforcement rate. The government's type follows a Markov process and therefore, can change at the beginning of each period. A trustworthy government is replaced by an opportunistic government with probability δ, and an opportunistic government may turn into a trustworthy one with probability ε.

Each period, the households simultaneously decide whether to *trust* or *suspect*. A trusting household determines the amount of formal and informal labor supply assuming that the government will commit to the tax policy it announces, while a suspecting household chooses the labor supplied for each sector assuming that the government will deviate and impose a positive tax rate. The sectors differ in terms of the technology used in the production process. The formal sector production function is of the form $y_F = \theta_F N_F$, where the informal sector's production function is given by $y_I = \theta_I N_I^{\gamma}$, with $\gamma \in (0,1)$. Informal and formal sectors produce a homogeneous good. Labor supply is inelastic, and normalized to 1.

The fraction of trusting households at period i, μ_i, is observable by the government and the households, but households cannot affect it individually. After observing μ_i, government moves. The trustworthy government commits to the announced tax policy; the opportunistic government, however, either commits or deviates. Note that once the government deviates, the households will be sure that they face an opportunistic government. Nevertheless, the next period's government will not necessarily be an opportunistic one, since there is a positive probability, ε, that the opportunistic government is replaced by a trustworthy government.

1.3 Household optimization

Each period, households choose the amount of labor supply for the formal and informal sectors. Trusting households choose the labor input for each sector that solves

$$\max_{N_F^t, N_I^t} \log(c^t)$$

subject to

$$c^t \leq \theta_F N_F^t + \theta_I (N_I^t)^{\gamma},$$

and

$$N_F^t + N_I^t = 1.$$

Therefore, the optimal amount of informal labor for trusting households is given as:

$$\hat{N}_I^t = \left(\frac{\gamma \theta_I}{\theta_F} \right)^{\frac{1}{1-\gamma}}.$$

On the other hand, suspecting households determine the labor input for each sector that solves

$$\max_{N_F^s, N_I^s} \log(c^s)$$

subject to

$$c^s \leq (1-\tau)\theta_F N_F^s + (1-\phi\tau)\theta_I (N_I^s)^\gamma,$$

and

$$N_F^s + N_I^s = 1.$$

Hence, the optimal level of informal labor supplied to the informal sector for the suspecting households is

$$\hat{N}_I^s = \left(\frac{(1-\phi\tau)\gamma\theta_I}{(1-\tau)\theta_F} \right)^{\frac{1}{1-\gamma}}.$$

The households' actual utility depends on the government's decision on the tax level. If the government commits to the policy, the level of consumption for the trusting households will be

$$c^{tc} = \theta_F \hat{N}_F^t + \theta_I (\hat{N}_I^t)^\gamma,$$

and the suspecting household's consumption will be

$$c^{sc} = \theta_F \hat{N}_F^s + \theta_I (\hat{N}_I^s)^\gamma.$$

On the other hand, if the government deviates, the level of consumption for the trusting household will be

$$c^{td} = (1-\tau)\theta_F \hat{N}_F^t + (1-\phi\tau)\theta_I (\hat{N}_I^t)^\gamma,$$

and the consumption of suspecting household will be

$$c^{sd} = (1-\tau)\theta_F \hat{N}_F^s + (1-\phi\tau)\theta_I (\hat{N}_I^s)^\gamma.$$

For notational simplicity, let $u^{ij} \equiv u(c^{ij})$, $\hat{y}_F^i \equiv \theta_F \hat{N}_F^i$ and $\hat{y}_I^i \equiv \theta_I (\hat{N}_I^i)^\gamma$ for $i = \{t, s\}$ and $j = \{c, d\}$.

1.4 Equilibrium

Let the Markov perfect equilibrium in this economy be characterized by the mixed strategies of the household and the government, $(\hat{\mu}(\rho), \hat{\pi}(\rho))$. Households' decision between trusting or suspecting depends on whether the probability that the government deviates in the current period is less than or equal to a cutoff value π^*, which is characterized by the following equation.

$$(1-\pi^*)u^{tc} + \pi^* u^{td} = (1-\pi^*)u^{sc} + \pi^* u^{sd}$$

Therefore,

$$\pi^* = \frac{u^{sc} - u^{tc}}{u^{td} + u^{sc} - u^{tc} - u^{sd}}$$

Let ρ denote the households' belief that the government is trustworthy. Therefore, $\rho^* = 1 - \pi^*$ is the cutoff belief that the government is trustworthy, above which all households trust the government, i.e. $\hat{\mu} = 1$ for all π.

If the government commits in period i when it was expected to deviate with probability π, Bayesian updating gives the probability of having a trustworthy government as

$$\begin{aligned} Pr(\mathrm{t}|\mathrm{c}) &= \frac{Pr(\mathrm{t})Pr(\mathrm{c}|\mathrm{t})}{Pr(\mathrm{t})Pr(\mathrm{c}|\mathrm{t}) + Pr(\mathrm{o})Pr(\mathrm{c}|\mathrm{o})} \\ &= \frac{\rho}{\rho + (1-\rho)(1-\pi)} \end{aligned}$$

at the end of period i. It implies that the households' belief of having a trustworthy government at the beginning of period $i+1$ is

$$\rho'(\rho, \pi) = (1-\delta)\left[\frac{\rho}{\rho + (1-\rho)(1-\pi)}\right] + \varepsilon\left[1 - \frac{\rho}{\rho + (1-\rho)(1-\pi)}\right]$$

Let $\hat{\pi}(\rho) = \frac{\pi^*}{1-\rho}$ for $\rho < \rho^*$, and $\hat{\pi}(\rho) = 1$ for $\rho \geq \rho^*$, so that the opportunistic government leaves the households indifferent between trusting and suspecting. Then, the belief of the households next period becomes

$$\rho'(\rho) = \left[\frac{\rho(1-\delta-\varepsilon)}{\rho^*}\right] + \varepsilon$$

Under this government reputation schedule, if the government commits for T periods after a deviation, we have $\rho_i < \rho^*$ for $i = 0, \ldots, T-1$, and $\rho_T \geq \rho^*$.

Finally, we find the fraction of trusting households $\hat{\mu}_i$ that guarantees that the opportunistic government becomes indifferent between committing to and deviating from the announced policy. For $i = 0, \ldots, T-1$,

$$
\begin{aligned}
V_i &= \beta V_{i+1} \\
V_i &= \hat{\mu}_i(\tau \hat{y}_F^t + \phi \tau \hat{y}_I^t) + (1 - \hat{\mu}_i)(\tau \hat{y}_F^s + \phi \tau \hat{y}_I^s) + \beta V_0 \\
V_T &= \tau \hat{y}_F^t + \phi \tau \hat{y}_I^t + \beta V_0
\end{aligned}
$$

where $\tilde{\beta}$ is the discount factor and $\beta = \tilde{\beta}(1 - \varepsilon)$ is the effective discount factor for the opportunistic government. This system of equations has a unique solution for the households' mixed strategy in equilibrium, $\hat{\mu}_i$, for $i = 0, \ldots, T-1$. Therefore,

$$
\hat{\mu}_i = \frac{\dfrac{(\phi \tau \hat{y}_I^t + \tau \hat{y}_F^t)(\beta^{T-i} - \beta^{T+1})}{1 - \beta^{T+1}} - (\phi \tau \hat{y}_I^s + \tau \hat{y}_F^s)}{\phi \tau (\hat{y}_I^t - \hat{y}_I^s) + \tau (\hat{y}_F^t - \hat{y}_F^s)}
$$

The solution for $\hat{\mu}_i$ satisfies that $\hat{\mu}_T = 1$ as we assume.

Therefore, the informal labor supply after i periods following a deviation is given by

$$
\Psi_i = \hat{\mu}_i \hat{N}_I^t + (1 - \hat{\mu}_i) \hat{N}_I^s,
$$

and the ratio of informal output to the total output in the economy in period i is

$$
\xi_i = \frac{\hat{\mu}_i \hat{y}_I^t + (1 - \hat{\mu}_i) \hat{y}_I^s}{\hat{\mu}_i (\hat{y}_I^t + \hat{y}_F^t) + (1 - \hat{\mu}_i)(\hat{y}_I^s + \hat{y}_F^s)}.
$$

1.5 Results

Using the equilibrium strategies by the government and the households, a comparison between full commitment economy and the economy in-hand can be made regarding the level of informal labor and the amount of informal output as percentage of the total output.

Proposition 1. In an economy described above, the amount of informal labor is at least as much as the one in a full commitment environment.

Proof. If all governments compulsorily commit to the announced tax policy, all households will act trustingly. Therefore, the amount of informal labor will be

$$\hat{N}_I = \hat{N}_I^t = \left(\frac{\gamma\theta_I}{\theta_F}\right)^{\frac{1}{1-\gamma}}.$$

Since $0 \leq \phi < 1$, $\frac{1-\phi\tau}{1-\tau} > 1$, this will imply $\hat{N}_I < \hat{N}_I^s$. Since $0 < \mu_i \leq 1$ for $i = 0, \ldots, T$ with an equality for $i = T$, we have $\hat{N}_I \leq \mu_i \hat{N}_I^t + (1-\mu_i)\hat{N}_I^s$ with an equality for $i = T$. □

Proposition 2. In an economy described above, the ratio of informal output to the total output is at least as much as the one in a full-commitment environment.

Proof. As shown in the previous proof, the amount of informal labor in the full commitment case will be $\hat{N}_I = \hat{N}_I^t$. Suppose $\bar{\xi}$ denotes the ratio of informal output to the total output in the full commitment case. Then, since

$\mu_i \in (0,1]$ for all i,

$$\begin{aligned}
\xi_i \geq \bar{\xi} \iff & \frac{\theta_I(\hat{N}_I^t)^\gamma}{\theta_I(\hat{N}_I^t)^\gamma + \theta_F \hat{N}_F^t} \leq \frac{\theta_I(\hat{N}_I^s)^\gamma}{\theta_I(\hat{N}_I^s)^\gamma + \theta_F \hat{N}_F^s} \\
\iff & B^\gamma(\theta_I(\hat{N}_I^t)^\gamma + \theta_F(1-\hat{N}_I^t)) - \theta_I B^\gamma(\hat{N}_I^t)^\gamma - \theta_F(1-B\hat{N}_I^t) \geq 0 \\
\iff & \theta_F(B^\gamma - B^\gamma \hat{N}_I^t - 1 + B\hat{N}_I^t) \geq 0 \\
\iff & \theta_F((B^\gamma - 1) + \hat{N}_I^t(B - B^\gamma)) \geq 0
\end{aligned}$$

where $B \equiv \left(\frac{1-\phi\tau}{1-\tau}\right)^{\frac{1}{1-\gamma}} > 1.$ $\square$

These two propositions show that differences in government reputation lead to the differences in the level of informality. Households in economies with lower trust in the government do not respond to the policy announcements the same way as the ones in the countries with highly trusted governments. In the presence of uncertainty about government commitment, the level of informality in terms of the labor supplied and the output produced stays higher compared to the economies with a government with full commitment.

1.6 Conclusion

In this paper, we show that public trust that manifests itself in the presence of an informational asymmetry about the true type of government in power may account for the size of an informal sector. We characterize the dynamics of the process of reputation formation of an opportunistic government, i.e. the type of government that doesn't necessarily commit to the plan that it announces, and argue that the higher levels of informality can be explained by examining this process. By using a model similar to the one proposed by Phelan (2006), we find a Markov perfect equilibrium where an opportunistic government plays a mixed strategy, rather than always deviating, to build reputation among the households.

CHAPTER 2
FISCAL, FINANCIAL AND LABOR MARKET RISKS: A MODEL-BASED ESTIMATION

2.1 Introduction

The relation between uncertainty in the economy, which is called in this chapter as risk, and the economic performance is investigated by many. The seminal paper by Ramey and Ramey (1995) shows that the size of volatility in an economy is related to growth. They show that higher volatility is associated with lower rate of growth for a set of 92 countries. By arguing that there is a relation between aggregate volatility and growth and supporting their argument by using econometric methods, they challenged the assumption in the growth literature that business cycles and growth are unrelated.

Traditional, regression-based approaches that utilizes past data to build a risk measure for a set of countries for different time periods are prone to the critique that the household's and government's behavior may adjust to the conditions so that the past relationships between the macroeconomic aggregates are no longer valid. Hence, there is a need to build a model-based risk measure which uses widely accepted macroeconomic models and tools that enable us to predict future behavior of agents without being susceptible to the "Lucas Critique".

There are several studies that use model based approaches to examine the effect of uncertainty on economic activity. Fernández-Villaverde, Guerrón-Quintana, Rubio-Ramírez, and Uribe (2011) studies the effect of the volatility in the real interest rate on the macroeconomic aggregates like output, consumption and investment in the emerging economies. They introduce a stochastic volatility process for real interest rate and estimate it by using Bayesian and particle filter methods. They use the estimated process for real interest rate in an open economy RBC model with parameters calibrated to match data for the selected countries. They find that the increase in the volatility in the real interest rate accounts for the fall in the economic activity. Fernández-Villaverde, Guerrón-Quintana, Kuester, and Rubio-Ramírez (2015) focuses on the impact of uncertainty changes in fiscal policy on the economic activity. They introduce government policy processes regarding tax and spending with time varying volatility process and estimate it by using the US data. Next, they estimate both a VAR model and a New Keynesian model to find the effect of uncertainty in the fiscal policy volatility on the macroeconomic variables such as output, consumption and hours worked. They conclude that an increase in the uncertainty in the volatility of fiscal policy results in a decline in economy activity.

In this chapter, we develop a model-based approach to create measures of different types of economic risks, namely fiscal risk, financial risk and labor market risk, for a panel of countries. We use an annual cross-country panel dataset that includes fiscal policy variables, labor market variables, and financial variables to explain their effect on the variation in total productivity. Following the tradition in macroeconomics started by Kydland and Prescott (1982), we introduce shocks to productivity and several other fiscal, financial and labor market variables exogenously. Using the estimated TFP series, we run a DSGE model by calibrating model parameters to match several moments in the data so as to obtain measures for fiscal, financial and labor market risks. This exercise allows us to construct a model-based dataset of three categories of risks mentioned above, and to calculate the "true welfare costs" of different kinds of country-specific risks.

The rest of this chapter is organized as follows. In Section 2, we introduce the benchmark macroeconomic model. In Section 3, we describe the scope and sources of the data. In Section 4, we describe the methods used for calibrating model parameters. In Section 5, we describe the procedure to calculate the three kinds of risk by using our model and the data. In Section 6, we present our results; and in Section 7, we conclude.

2.2 The model

The representative household maximizes their utility with respect to their budget constraint. The utility function of the household is of the form

$$U(c, \ell) = \mathbb{E} \sum_{t=0}^{\infty} \beta^t (\log c_t + \psi \log(1 - \ell_t)),$$

where c_t is the amount of consumption at time t and ℓ_t is the amount of labor supplied for production. β denotes the discount rate, and ψ stands for the weight of leisure in the utility function. Therefore, the function $U(\cdot)$ represents the expected discounted lifetime utility for the representative household.

The household earns revenue by renting capital and supplying their labor to the production and get rents and wage in return. However, δ fraction of capital depreciates each period. Therefore, the budget constraint for the household for $t = 0, 1, 2, \ldots$ is as follows:

$$c_t + i_t = w_t \ell_t + r_t k_t$$

where $k_{t+1} = (1 - \delta)k_t + \kappa i_t$.

We assume that the production in the economy is of the neoclassical form. One homogeneous good is produced in the economy by utilizing capital and labor. Mathematically, the production function is

$$y_t = F(k_t, \ell_t) = k_t^{\alpha}(e^{z_t}\ell_t)^{1-\alpha}$$

The τ fraction of output is collected by the government as tax. Therefore, there remains $(1 - \tau)y_t$ amount of output in the hands of the representative firm. Therefore, the firm's problem is to find the optimal k_t, ℓ_t, given r_t and w_t, that solves

$$\max_{k_t, \ell_t} k_t^{\alpha}(e^{z_t}\ell_t)^{1-\alpha} - \tau k_t^{\alpha}(e^{z_t}\ell_t)^{1-\alpha} - w_t \ell_t - r_t k_t$$

subject to $k_t, \ell_t \geq 0$ for all $t \geq 0$. The first-order conditions requires that

$$r_t = (1 - \tau)\alpha k_t^{\alpha-1}(e^{z_t}\ell_t)^{1-\alpha}$$

for $t = 0, 1, 2, \ldots$; and

$$w_t = (1 - \tau)(1 - \alpha)k_t^{\alpha}(e^{z_t})^{1-\alpha}\ell_t^{-\alpha}$$

for $t = 0, 1, 2, \ldots$.

We assume that the production technology, z_t, evolves over time following an AR(1) process.

$$z_t = \rho z_{t-1} + \varepsilon_t,$$

where $\varepsilon_t \sim \mathcal{N}(0, \sigma^2)$.

The benevolent government collects a certain amount of output in the economy, and throws into the ocean. The fraction of output collected by the government is τ.

The competitive equilibrium in this economy is the sequence of allocations $\{c_t, i_t, \ell_t\}_{t=0}^{\infty}$ and the sequence of prices $\{w_t, r_t\}_{t=0}^{\infty}$ such that given $\{w_t, r_t\}_{t=0}^{\infty}$, the sequence $\{c_t, i_t, \ell_t\}_{t=0}^{\infty}$ solves the representative household's and the representative firm's problems, and the markets clear.

Since our model satisfies the conditions for both welfare theorems, we can solve instead the social planner's problem. The social planner's problem is to maximize the expected discounted lifetime utility subject to the resource constraint in the economy and the law of motion for capital and technology.

$$\max \mathbb{E} \sum_{t=0}^{\infty} \beta^t (\log c_t + \psi \log(1 - \ell_t))$$

subject to

$$y_t = c_t + i_t + g_t$$

$$g_t = \tau y_t$$

$$k_{t+1} = (1 - \delta) k_t + \kappa i_t$$

$$z_t = \rho z_{t-1} + \varepsilon_t$$

for $t = 0, 1, 2, \ldots$ and $\varepsilon_t \sim \mathcal{N}(0, \sigma^2)$.

The solution to the Social Planner's Problem gives the following equations as the characterization of the equilibrium.

$$
\begin{aligned}
\frac{1}{c_t} &= \beta E_t \left(\frac{1}{c_{t+1}} (\alpha k_{t+1}^{\alpha-1} (e^{z_{t+1}} l_{t+1})^{1-\alpha} + 1 - \delta) \right) \\
\psi \frac{c_t}{1 - l_t} &= (1-\alpha) k_t^{\alpha} (e^{z_t} l_t)^{1-\alpha} l_t^{-1} \\
c_t + i_t + g_t &= k_t^{\alpha} (e^{z_t} l_t)^{1-\alpha} \\
k_{t+1} &= (1-\delta) k_t + \kappa i_t \\
z_t &= \rho z_{t-1} + \varepsilon_t \\
g_t &= \tau k_t^{\alpha} (e^{z_t} l_t)^{1-\alpha}
\end{aligned}
$$

2.3 Data

We use data for 41 countries across the world for the period between 1970 and 2009. We obtain data for the level of employment and annual hours worked per employed from Total Economy Database 1950-2015 dataset. The series for the GDP, capital stock, government expenditures as percentage of GDP and consumption as percentage of GDP are obtained from Penn World Tables, version 8.1. Finally, the World Bank's Global Financial Development Database (GFDD) that covers the period between 1960 and 2013 provides the data for liquid liabilities (M3).

The series for labor wedge, defined as the ratio of marginal rate of substitution between labor and consumption (MRS) to the marginal product of labor (MPL), and the TFP series, are calculated by using the above-mentioned data as they are characterized in our model.

2.4 Calibration

The calibration of our model consists of two parts. There are 4 exogenously chosen parameters in the model. The α parameter in the production function is chosen to be 0.33, and the depreciation parameter, δ, is chosen to be 0.04 in line with the RBC literature. Additionally, κ is calibrated to 0.9, and τ is chosen to be equal to 0.2.

The rest of the parameters are determined within the system. First, we calibrate β as follows. One of the equations in the equilibrium characterization is

$$\frac{1}{c_t} = \beta E_t \left(\frac{1}{c_{t+1}} (\alpha k_{t+1}^{\alpha-1} (e^{z_{t+1}} \ell_{t+1})^{1-\alpha} + 1 - \delta) \right)$$

Suppose that the motion of technology is deterministic, i.e. $\sigma = 0$. Then, the above equation becomes

$$\frac{1}{c_t} = \beta \left(\frac{1}{c_{t+1}} (\alpha \frac{y_{t+1}}{k_{t+1}} + 1 - \delta) \right).$$

Then, we can find the value of the parameter β for each period by using the data for consumption at time t and $t+1$, the output at $t+1$ and the capital stock at $t+1$. Finally, we take the arithmetic average of the β's to determine the calibrated β that will be used. This exercise is conducted for the whole set of countries in our dataset.

Second, we calibrate ψ, the weight of leisure in the utility function, as follows. The characterization of the equilibrium includes the following equation.

$$\psi \frac{c_t}{1-\ell_t} = (1-\alpha)\frac{y_t}{\ell_t}$$

Therefore, we can find the value for ψ by using the data for GDP, consumption and total hours worked, which is calculated by multiplying the level of employment by the hours worked per employed. To normalize the level of total hours worked, we divide it by the total available time to the employed, which is calculated by the multiplication of total hours in a year by the number of employed. Once we find the value of ψ for each period, we set the value of ψ equal to the arithmetic average of those values. This exercise is repeated to find ψ values for each country in our dataset.

TFP series for each country are generated by using the analytical model and the associated data in order to find the parameter estimates that governs the law of motion for TFP. First, we generate the TFP series by using the data for GDP, capital stock and the total hours worked each year.

$$z_t = \frac{1}{1-\alpha}\log\left(\frac{y_t}{k_t^{\alpha}\ell_t^{1-\alpha}}\right)$$

We demean and detrend the TFP series by regressing it on a constant and a linear time trend:

$$z_t = \gamma_0 + \gamma_1 t + u_t$$

Then we use the estimated residuals, $\hat{u}_t \equiv \hat{z}_t - z_t$, as the detrended TFP series that will be used for the rest of the study to find the parameters that govern

AR(1) process:

$$\hat{u}_t = \phi_0 + \phi_1^z \hat{u}_{t-1} + e_t^z,$$

where ϕ_1^z will be used as the persistence parameter of TFP, ρ, and the standard error of e^z, s_z, will be the parameter estimate for σ.

2.5 Introduction of fiscal, financial and labor market risks

Our goal is to decompose the variation in TFP into different sources that leads to it, and we choose fiscal, financial and labor market variables that may account for this variation. We intend to find the equivalent fiscal, financial and labor market shocks which are present indirectly through TFP in the benchmark model.

Suppose the amount of government expenditures, g_t, is prone to stochastic shocks in the following form:

$$g_t = \tau y_t + \varepsilon_t^g,$$

where $\varepsilon_t^g \sim \mathcal{N}(0, \sigma_g^2)$ for $t = 0, 1, 2, \ldots$. Therefore, what governs the motion of government expenditures is the variation in ε_t^g, i.e. σ_g, which we will call "fiscal risk" for the rest of this study.

In the same fashion, we introduce an uncertainty in the κ parameter in the following manner.

$$\kappa_t = \kappa + \varepsilon_t^\kappa,$$

where ε_t^κ is normally distributed with mean zero and variance σ_κ^2. Therefore, σ_κ will be the financial risk measure that we are going to estimate.

Finally, to introduce an uncertainty for the labor supply decision, suppose the weight of leisure in the utility function, ψ, as follows.

$$\psi_t = \psi + \varepsilon_t^\psi,$$

where $\varepsilon_t^\psi \sim \mathcal{N}(0, \sigma_\psi^2)$ for $t = 0, 1, 2, \ldots$. Hence, σ_ψ will be the parameter that will be estimated by our model and called "labor market risk".

To account for the effects of variation in fiscal, financial and labor market variables on the variation in productivity in the data, we regress the demeaned and detrended TFP series, $\hat{u}_t$, for each country on the variables associated with each risk category. We conduct each of the following regressions separately for each country.

First, we regress $\hat{u}$ on its first lag, the government's share in GDP, gy, and a constant.

$$\hat{u}_t = \phi_0^g + \phi_1^g \hat{u}_{t-1} + \phi_2^g gy_t + e_t^g$$

We use ϕ_1^g as the new persistence parameter estimate, and the standard error of e^g, s_g, as the estimate for σ_z for the model that include fiscal risk component.

Secondly, we regress $\hat{u}$ on its first lag, the liquid liabilities, $m3$, and a constant.

$$\hat{u}_t = \phi_0^\kappa + \phi_1^\kappa \hat{u}_{t-1} + \phi_2^\kappa m3_t + e_t^\kappa$$

To feed the model with the financial risk introduced, we use ϕ_1^κ as the persistence parameter for the TFP; and the standard error of e^κ, s_κ, as σ_z.

Finally, we regress $\hat{u}$ on its first lag, a constant, and the labor wedge, lw.

$$\hat{u}_t = \phi_0^\psi + \phi_1^\psi \hat{u}_{t-1} + \phi_2^\psi lw_t + e_t^\psi$$

Then, ϕ_1^ψ is used as the persistence of TFP, and the standard error of e^ψ, s_ψ, is utilized as the standard deviation of the error term for the law of motion for TFP, σ_z in the model with labor market risk.

2.6 Results

There are four different models at hand. The first one is the model with no fiscal, financial or labor market risk introduced. In order to estimate this model, we use $\beta, \alpha, \kappa, \psi, \tau$ and δ as defined in Section 4, and we use ϕ_1^z and s^z as ρ and σ, respectively. The second model is the one in which fiscal risk is included. To run the model, we use the same $\beta, \alpha, \kappa, \psi, \tau$ and δ, and we use ϕ_1^g and s^g as ρ and σ, respectively. The third model includes only the financial risk as an addition to the first model. We feed the model with the same $\beta, \alpha, \kappa, \psi, \tau$ and δ, and use ϕ_1^κ as ρ and s^κ as σ. The fourth model, the one with the labor market risk component included to the first model, is estimated by using the same $\beta, \alpha, \kappa, \psi, \tau$ and δ values, and with the use of ϕ_1^ψ as ρ and s^ψ as σ.

During this procedure, what we are after are the estimates for σ_g, σ_κ and σ_ψ, namely the fiscal, financial and labor market risk parameters. These are the ones that we need to find by using the four models at hand. In order to find estimates for these parameters, the following procedure is applied. First, the first model is run by using the method explained above, and the standard deviation of $\log(y)$ is estimated. Next, the second model is used to estimated with a vector of different values for s_g. The s_g value that produces the same variation in the logarithm of the output in the economy, $\log(y)$, is considered the correct estimate for σ_g. The same exercise is conducted to find estimates for σ_κ and σ_ψ. The entire procedure is repeated for the whole set of countries in our dataset.

The model-based fiscal risk estimates are shown in Table 1.

Table 1. Fiscal risk estimates, 1970-2009

Argentina	0.0966	Ireland	0.0016
Australia	0.0099	Italy	0.0147
Austria	0.0088	Malaysia	0.0326
Bangladesh	0.0300	Mexico	0.0135
Belgium	0.0054	Netherlands	0.0205
Brazil	0.0271	New Zealand	0.0094
Canada	0.0084	Peru	0.0786
Chile	0.0192	Philippines	0.0150
China	0.3211	Portugal	0.0128
China-Hong Kong	0.0274	Singapore	0.0579
Colombia	0.0171	Sri Lanka	0.0102
Finland	0.0770	Sweden	0.0055
Greece	0.0311	Switzerland	0.0072
Iceland	0.1266	Thailand	0.0947
India	0.0302	United States	0.0135

Table 2 presents the financial risk estimates generated by the model for the period 1970-2009 for a number of countries.

Table 2. Financial risk estimates, 1970-2009

Australia	0.1507	Malaysia	0.3632
Austria	0.1039	Mexico	0.4000
Bangladesh	0.8493	Netherlands	0.3037
Belgium	0.3942	New Zealand	0.1973
Brazil	0.2714	Pakistan	0.1764
Canada	0.2766	Philippines	0.2526
Chile	0.4811	Portugal	0.4301
China-Hong Kong	0.9196	Republic of Korea	0.3512
Colombia	0.2532	Singapore	0.5213
Finland	0.5775	Spain	0.3813
France	0.3934	Sri Lanka	0.4966
Germany	0.2853	Sweden	0.4648
Greece	0.2517	Switzerland	0.1292
Iceland	0.8100	Thailand	0.4134
India	0.6831	Turkey	0.3097
Indonesia	0.3928	United Kingdom	0.3907
Ireland	0.6169	United States	0.0850
Italy	0.3922	Venezuela	0.7045
Luxembourg	0.3517		

Finally, the labor market risk for a panel of countries in the period between 1970 and 2009 are shown in Table 3.

Table 3. Labor market risk estimates, 1970-2009

Argentina	0.0368	Luxembourg	0.0789
Australia	0.0123	Malaysia	0.0664
Bangladesh	0.0454	Mexico	0.0356
Belgium	0.0463	Netherlands	0.0493
Brazil	0.0338	New Zealand	0.0194
Canada	0.0268	Pakistan	0.0153
Chile	0.0825	Peru	0.0241
China	0.0846	Philippines	0.0182
China-Hong Kong	0.0503	Portugal	0.0274
Colombia	0.0143	Republic of Korea	0.0366
France	0.0530	Singapore	0.0792
Germany	0.0394	Sri Lanka	0.0259
Greece	0.0364	Sweden	0.0388
Iceland	0.0242	Switzerland	0.0168
India	0.0626	Thailand	0.0205
Indonesia	0.0554	Turkey	0.0456
Ireland	0.0444	United Kingdom	0.0194
Italy	0.0322	United States	0.0154
Japan	0.0518	Venezuela	0.0556

2.7 Conclusion

In this chapter, we propose a novel, model-based risk measure in order to decompose the sources of variation in output into three; namely fiscal risk, financial risk and labor market risk. To this end, we build a parsimonious dynamic stochastic general equilibrium model in which the parameters are estimated either exogenously, or by time-series methods, or in the model. By running the benchmark model with no decomposition of risk factors, and three different models that each includes only one kind of risks, we generate a dataset of fiscal, financial and labor market risks for the period 1970-2009 for 41 countries. This dataset allows us to analyze welfare costs of each risk factor for each country by using the same macroeconomic model. Additionally, the correlation of different types of risks with one another, and with other macroeconomic variables can be investigated.

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