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Underground economy and aggregate fluctuations

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Abstract. This paper explores the role of underground economic activities as an explanation of differences in registered aggregate fluctuations. In order to do so, we introduce an underground economy sector in an otherwise standard Real Business Cycle model and calibrate it to the USA economy. We find that, at low frequencies, Europe fluctuates more than the USA, while its participation rate is smaller. The existence of underground activities rationalizes the negative relationship between participation rates and fluctuations of registered output. Our model accounts for 44.3% of the differences in aggregate fluctuations between the USA and European economies. Finally, the model generates implied sizes of the underground economy of 3.2% and 7% of the American and European output, respectively, which are in the range of those found in the empirical literature.

JEL classification: E24, E32, O017

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1 Introduction

This paper explores the role of underground economic activities as an explanation of differences in registered aggregate fluctuations. In order to do so, we introduce an underground economy sector in an otherwise standard Real Business Cycle

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model and calibrate it to the USA economy. Then, we explore the role of differences in participation rates in order to understand differences in fluctuations. In standard models, the level of the participation rate does not have an effect on the range of fluctuations; however, due to the existence of underground activities, it does in our model.

The empirical evidence shows that the standard deviation of registered output is higher at high frequencies in the USA than in Europe, while at low frequencies this fact is reversed. At the same time, the participation rate of the working-age population in the registered economy is smaller in Europe than in the USA. The observation that average participation rates are negatively related to low frequency fluctuations of output is robust, given that it is observed also when doing international comparisons with a wide range of countries. We focus on this negative relationship and propose a theoretical framework that rationalizes this observation, due to the existence of underground economic activities. In our framework, a smaller participation rate would imply that in response to the same technological shocks, more individuals will move in or out of the registered economy inducing bigger fluctuations. Thus, an economy with a low participation rate will have a larger underground economy sector and larger fluctuations of registered economic activities.

We show how economies that only differ in their wage premia will respond differently to the same technological shocks. A smaller wage premium implies smaller participation rates and therefore a larger size of the underground economy and higher fluctuations in registered activities. Our main result is that exogenously specified differences in the wage premium, as observed in the data, could account for 44.3% of the differences in aggregate fluctuations between the USA and European economies. Also, including underground activities improves the performance of the model in accounting for the empirical facts. Finally, our analysis allows us to derive indirect estimates of the size of underground economic activities depending on the average participation rate.

There exists a large body of literature concerned with the quantification of the relative size of the underground economy. These quantification attempts use a variety of methodologies that yield quite different results. Moreover, since the term “underground economy” is not easy to identify conceptually, the divergence in quantitative estimates could arise simply because of the difference in the object subject to study. Consequently, it is essential to clearly specify what kind of activities we are referring to.

We will call “underground economy” (or underground economic activities) to the production of goods and services that could otherwise be provided through registered market channels, but are object of economic transactions not registered in national income and product accounts. Therefore, we are referring to underground economy exclusively as an alternative way to provide the same goods and services than the registered market does. This definition does not include transactions of illegal commodities or services. Also, activities such as household production are not included in the definition provided since they refer to activities not traded at market prices. Finally, our definition does not include tax evasion in its strict sense, since it does not imply production of goods or services. However, market transactions hidden for tax evasion purposes would be considered underground economic activities.

In standard Real Business Cycle (RBC) models, fluctuations are driven by a stochastic Markov process of technological shocks. Moreover, differences in average participation rates are independent of the size of the fluctuations of output. Our aim is to explore how economies that face the same technological shocks could respond differently when underground activities are included, given their differences in participation rates. Our measure of aggregate fluctuations will be the standard deviation of detrended output.

In our model, individuals face two labor decisions in two stages: first, whether or not to participate in registered economic activities and, second, if they decide to engage in underground activities, how many hours dedicate to them. Therefore, we will consider labor to be indivisible in the registered economy. Individuals will take the first decision based on the wage premium, defined to be the ratio of average market wages in registered economic activities to the minimum wage. If we assume that workers could make the minimum wage working full time in underground activities, the wage premium would be the opportunity cost of not participating in registered activities. Based on this opportunity cost, we endogenously get the participation rate in registered activities (defined as the ratio of registered employment to working age population) which, together with the optimal amount of hours worked in underground activities and their productivity, will allow us to obtain implicit estimates of the size of the underground economy.

Such a framework is somewhat related in methodology to the household production literature (see Benhabib et al. 1991, and McGrattan et al. 1997). Our framework differs from theirs, though, in two important issues: first, we consider commodities produced in both sectors as perfect substitutes which are tradable at market prices; second, we assume labor to be indivisible in registered activities. While hours worked in registered activities are exogenously fixed, in underground activities they are freely chosen.

Hansen (1985) introduces labor indivisibilities in a standard RBC model. This approach is supported by the empirical evidence that two thirds of changes in aggregate hours worked can be attributed to the extensive margin, i.e. movements in and out of employment rather than changes in the number of hours worked by individuals. The performance of the model improves in terms of accounting for the business cycle facts in the USA economy. Rogerson (1987) provides the theoretical framework to handle indivisibilities. We rely on that framework in the registered economy, where working time decisions are contracted exogenously. Therefore, the only remaining decision is whether to participate or not in registered economic activities.

The rest of the paper is organized as follows. Section 2 presents the empirical evidence and motivation. Section 3 presents the model. Section 4 discusses the calibration and simulation procedures. Section 5 comments the simulations results. Section 6 analyzes the effects of changes in the wage premium. Conclusions are in Sect. 7.

2 Empirical evidence

We have made comparisons between the USA and a European aggregate[1] on yearly registered economic fluctuations, using the OECD *Main Economic Indicators* and the *Labor Force Statistics* (years 1962 to 1990). Fluctuations are measured by the standard deviation of the logarithm of the corresponding variable linearly detrended. The reason to use linearly detrended series is our focus on low frequency fluctuations. We observe that the European participation rate (that we define as employment over working age population) has been smaller on average than in the USA, while the European standard deviation of registered output is larger than in the USA. However, at high frequencies (e.g., filtering with the Hodrick-Prescott procedure and λ=10),[2] the standard deviation of output is 1.81% and 0.85% for the USA and Europe, respectively; numbers consistent with those found in the literature (see Backus et al. 1995).

The standard deviation of linearly detrended (log of) GDP in Europe is 5.14%, as compared to 3.65% for the USA, while average (period 1962–1990) participation rates are 62.2% and 66% for Europe and the USA, respectively. Also, fluctuations in investment are higher in Europe (9.1%) than in the USA (7.3%). Regarding the fluctuations in consumption, we observe again that fluctuations in Europe (5%) are higher than in the USA (3.2%), and in both cases smaller than fluctuations in output and investment, as usually reported in the RBC literature. Finally, notice that the standard deviation of participation rates is higher in Europe (1.85%) than in the USA (1.76%). Table 1 reports those statistics.

Table 1. Standard deviations of selected indicators

	USA	EU
Participation rate (mean)	0.660	0.622
Registered output	0.0365	0.0514
Consumption	0.0320	0.0501
Investment	0.0730	0.0910
Participation rate	0.0176	0.0185

Is there any issue, other than differences in technological shocks, that could account for cross country differences in aggregate registered fluctuations? Our goal is to isolate the effect attributable to the existence of an underground economy sector in explaining differences in registered aggregate fluctuations. Hence, we construct a model in which we introduce an underground economy sector that is able to display this kind of pattern; namely, that the participation rate in registered activities will have a negative effect on the degree of fluctuation of registered GDP.[3]

[1] The European aggregate includes the 12 European Comunity countries as of 1992.

[2] For arguments of why to use a value of $\lambda = 10$ for detrending annual data, see Baxter and King (1995) and Doménech et al. (1997).

[3] The negative relationship between participation rates and low frequency fluctuations is an empirical regularity observed in comparisons with a larger sample of countries.

The specific hypothesis we work with is that differences in institutional arrangements (that will not be explicitly modelled) between the USA and European economies generate differences in the wage premium and, therefore, in their participation rates. Europe, with a smaller participation rate, will display a larger underground economy sector and larger fluctuations of registered output. Thus, we quantify to what extent those differences in wage premiums could help understand the different patterns in fluctuations observed in the USA and Europe.

3 The model

There exists a continuum of measure one of ex-ante identical agents, equally endowed with one unit of time. Their expected utility at period 0 takes the form:

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t [U(c_t) + V(1 - h_{mt} - h_t)] \right\} \tag{3.1}$$

where c_t is consumption in period t, $h_{mt} \in \{0, h^*\}$ is the indivisible time spent working in registered activities, $h_t \in [0, 1]$ is time spent working in underground activities, and $\beta \in (0, 1)$ is the discount factor. Functions $U(\cdot)$ and $V(\cdot)$ are assumed to be continuously differentiable, monotonically increasing and strictly concave. Also, we will assume that $h_t = 0$ whenever $h_{mt} = h^*$, i.e. workers can only participate in one of the production sectors.

The production function in registered activities is given by $e^{z_t} f(K_t, H_{mt})$, where the function $f(\cdot)$ is assumed to be constant returns to scale, monotonically increasing, strictly concave in both arguments and to satisfy the Inada conditions; K_t is the amount of capital; H_{mt} is the total amount of labor in market activities; and z_t is a random shock that follows a stochastic first order Markov process.

Each worker in the underground economy has an individual production function that is given by $g(h_t)$, where $g(\cdot)$ is assumed to be strictly concave and h_t is the number of hours worked in underground activities. Due to the labor intensive specification of the production function for underground activities, we will assume that the technological shocks only affect the registered economy.

If we assume a perfectly insured market, we can interpret the decentralized competitive equilibrium as one in which agents purchase an infinite sequence of lotteries.[4] These lotteries are defined over consumption and hours worked in both activities. We define λ_t as the probability of working in underground activities at period t. Clearly, the probability of working in registered activities is $1 - \lambda_t$.

The economy behaves as follows: at the beginning of every period t, agents know the capital stock k_t and the realization of the stochastic shock z_t. Consumers, taking wages and rental rates for capital as given, will rent their capital stock to the firms in the registered economy, decide how much to save and choose a lottery, λ_t. This lottery implies the probability of not participating in the registered economy, therefore consuming c_{bt} and working h_t hours with their

[4] For a more detailed treatment of these issues, see Hansen (1985) and Rogerson (1987).

individual production function. Otherwise, with probability $1 - \lambda_t$, they work in the registered economy h^* hours, receive the competitive wage w_t and consume c_{mt}. The unique consumption good is homogeneous, regardless of whether it is produced in registered or in underground activities, and therefore it is sold at the same price in the market. Ex-post, according to the results of the lottery, the consumer will go to one of the two sectors. Firms in the registered economy will behave competitively. At the beginning of period t the shock is realized, and they hire capital and labor from the consumers, taking prices as given. Free entry and exit in the registered economy will imply zero profits.

By definition, $\lambda_t \in [0, 1]$. Since there exists a continuum of agents of measure one, by the Law of Large Numbers, λ_t will be ex-post the fraction of workers in underground activities. The total number of hours worked in registered activities is then $H_{mt} = (1 - \lambda_t)h^*$ and the aggregate production function of the underground economy is $\lambda_t g(h_t)$.

Definition of a sequential competitive equilibrium. In this economy, a sequential competitive equilibrium is a sequence of allocations $\{c_{mt}, c_{bt}, k_t, \lambda_t, h_t, H_{mt}, K_t\}_{t=0}^{\infty}$ and prices $\{w_t, r_t\}_{t=0}^{\infty}$ such that:

(i) Consumers choose $\{c_{mt}, c_{bt}, k_{t+1}, \lambda_t, h_t\}$ to solve the problem:

$$\max \quad E_0 \sum_{t=0}^{\infty} \beta^t [(1 - \lambda_t)(U(c_{mt}) + V(1 - h^*)) + \lambda_t(U(c_{bt}) + V(1 - h_t))] \tag{3.2}$$

$$s.t. (1 - \lambda_t)c_{mt} + \lambda_t c_{bt} + k_{t+1} - (1 - \delta)k_t \leq (1 - \lambda_t)w_t h^* + \lambda_t g(h_t) + r_t k_t \tag{3.3}$$

$\forall t$, given k_t, w_t, r_t and the initial capital stock k_0.

(ii) Firms choose $\{H_{mt}, K_t\}$ to solve:

$$\max \quad e^{z_t} f(K_t, H_{mt}) - w_t H_{mt} - r_t K_t \tag{3.4}$$

given z_t, w_t, r_t.
Free entry and exit implies zero profits.

(iii) Market clearing: $k_t = K_t$, $(1 - \lambda_t)h^* = H_{mt}$, $\forall t$.

(iv) Feasibility: $(1-\lambda_t)c_{mt} + \lambda_t c_{bt} + k_{t+1} - (1-\delta)k_t \leq e^{z_t} f(k_t, (1-\lambda_t)h^*) + \lambda_t g(h_t)$, $\forall t$.

It is straightforward to show that, given this framework, the Second Welfare Theorem applies. Therefore, we can specify the social planner's problem as one in which at every period t, $c_{mt}, c_{bt}, k_{t+1}, h_t$ (c_{mt} and c_{bt} denote consumption when working in registered and underground activities, respectively) and λ_t are chosen in order to solve the following maximization problem:

$$\max \quad E_0 \sum_{t=0}^{\infty} \beta^t [(1 - \lambda_t)(U(c_{mt}) + V(1 - h^*)) + \lambda_t(U(c_{bt}) + V(1 - h_t))] \tag{3.5}$$

$$s.t.(1-\lambda_t)c_{mt} + \lambda_t c_{bt} + k_{t+1} - (1-\delta)k_t \leq e^{z_t} f(k_t, (1-\lambda_t)h^*) + \lambda_t g(h_t) \quad (3.6)$$

Standard first order necessary conditions imply that at the optimum $c_{mt} = c_{bt}$. To see that, it suffices to show that first order conditions imply equality of the marginal utility of consumption in all possible events. Thus, the problem can be rewritten as:

$$\max_{c_t, k_{t+1}, \lambda_t, h_t} E_0 \sum_{t=0}^{\infty} \beta^t [U(c_t) + (1-\lambda_t)V(1-h^*) + \lambda_t V(1-h_t)] \quad (3.7)$$

$$s.t. \qquad c_t + k_{t+1} - (1-\delta)k_t \leq e^{z_t} f(k_t, (1-\lambda_t)h^*) + \lambda_t g(h_t) \quad (3.8)$$

The one-period objective function is continuous, strictly quasi-concave in its three arguments (c_t, λ_t, h_t) and the constraint set is convex. It should be noticed that the choice of (λ_t, h_t) is a static problem embodied in a dynamic framework. This is clear from the first order conditions with respect to those variables, equations (3.10) and (3.11). Therefore, the Kuhn-Tucker-Lagrange conditions are necessary and sufficient for a maximum. In addition, strict quasi-concavity implies unicity of the solution. Since first order conditions imply necessarily strictly positive amounts of (c_t, λ_t, h_t), the optimality conditions will be:

$$U'(c_t) = E_t\{U'(c_{t+1})\beta[1 + e^{z_{t+1}} f_1(k_{t+1}, (1-\lambda_{t+1})h^*) - \delta]\} \quad (3.9)$$

$$V(1-h_t) - V(1-h^*) = U'(c_t)[e^{z_t} f_2(k_t, (1-\lambda_t)h^*)h^* - g(h_t)] \quad (3.10)$$

$$V'(1-h_t) = U'(c_t)g'(h_t) \quad (3.11)$$

Condition (3.9) is the standard Euler condition. Condition (3.10) is the optimality condition for participation in registered activities. This decision is made based on the opportunity cost of not participating in market activities (the expression in brackets), that will be closely related to our definition of the wage premium. Finally, condition (3.11) is the optimality condition for the number of hours worked in underground activities.

4 Quantitative analysis and calibration procedure

4.1 Functional forms and steady-state computation

We choose the following functional forms:

$$U(c_t) = \log c_t \quad (4.1)$$

$$V(1-h_{mt}-h_t) = A\log(1-h_{mt}-h_t) \quad (4.2)$$

$$f(k_t, (1-\lambda_t)h^*) = k_t^{\theta}((1-\lambda_t)h^*)^{1-\theta} \quad (4.3)$$

$$g(h_t) = Bh_t{}^{\gamma} \quad (4.4)$$

where A and B are positive constants, $\theta \in (0,1)$ and $\gamma \in (0,1)$.

The technological shock is assumed to be of the form $z_t = \rho z_{t-1} + \varepsilon_t$, where ε_t is iid with normal distribution $(0, \sigma_\varepsilon^2)$.

The optimality conditions, given the functional forms assumed, yield in the deterministic steady-state the following equations:

$$1 = \beta[1 + \theta k^{\theta-1}[(1-\lambda)h^*]^{1-\theta} - \delta] \tag{4.5}$$

$$A\log(1-h) - A\log(1-h^*) = \frac{1}{c}\{(1-\theta)k^\theta[(1-\lambda)h^*]^{-\theta}h^* - Bh^\gamma\} \tag{4.6}$$

$$\frac{A}{1-h} = \frac{1}{c}B\gamma h^{\gamma-1} \tag{4.7}$$

Therefore, a deterministic steady state equilibrium would be characterized by values of the variables k, λ, h and c, such that they solve the optimality equations given by (4.5), (4.6) and (4.7), together with the feasibility constraint (satisfied with equality in equilibrium) in steady state: $c + \delta k = f(k, (1-\lambda)h^*) + \lambda g(h)$.

4.2 Parametrization and calibration

According to Ghez and Becker (1975) and Juster and Stafford (1991), households allocate one-third of their discretionary time to market activities. Therefore, the natural choice of h^* is 1/3, since we are restricting ourselves to underground economic activities versus registered activities.

The model has been calibrated to the USA economy. To compute the model, we follow Kydland and Prescott (1982) and approximate the objective function using a second order Taylor series expansion around its deterministic steady state. That yields a linear quadratic approximation of the problem, implying linear decision rules.

The capital share is chosen to be $\theta = 0.36$, which is standard in the RBC literature. The underground activity parameter γ has been chosen assuming that the production function for self-employed workers in the USA is of the same form (i.e. labor intensive with decreasing returns). Therefore, from the NIPA we have output and number of self-employed workers, so that we can estimate γ by OLS (roughly 0.65). Notice that this value implies that the individual production function in underground activities is roughly the same than the registered economy Cobb-Douglas production function with a fixed amount of capital.

The constant A is chosen so that the steady state value of λ matches the USA average registered participation rate for the period considered. In our calibration, we use employed population over working age population (66% on average in the last 3 decades, according to the *Labor Force Statistics* of the OECD).

In order to calibrate the constant B, we proceed as follows. We assume that the technology in the underground economy is such that workers can make the minimum wage by working full time in underground activities. We follow Mankiw et al. (1992) and assume that workers with no skill qualification would make the minimum wage. Then, the implicit assumption is that underground activities do not require any skills. We consider the wage premium (defined as the ratio of market wages to minimum wage) as a policy objective institutionally given. Different institutional arrangements (labor market regulations, mainly the minimum wage, tax policy, transfers and other welfare policies) can generate differences in wage premia for economies otherwise equal. We consider those differences as exogenously given in our model. Therefore, B is chosen so that in steady state, and for the same amount of hours worked in both technologies, the relative efficiency of one sector with respect to the other is such that the wage premium matches the ratio between average wage and minimum wage for the USA. Mankiw et al. (1992) derived an estimate of 2 for the average 1960-90 USA wage premium. We will use that figure as a benchmark for simulation purposes.

Thus, we determine the steady state values of the endogenous variables k, λ, h and c, together with the value of the constant B which is consistent with a steady state wage premium equal to 2. We do so by introducing an additional condition for the steady state computation to pin down the parameter B: $w/B(1/3)^{\gamma-1} = 2$, where w denotes the steady-state market wage. Therefore, the calibration of the parameter B and the computation of the steady state are done simultaneously. The result is a steady state equilibrium that satisfies the additional condition that a worker in the registered sector would make twice as much per hour than working in the underground economy. The constant B is then held fixed for the simulations of the stochastic version of this economy.

Finally, σ_ε is chosen to match the USA aggregate registered fluctuations, an standard deviation of detrended (log of) GDP of 0.0365, so that we choose $\sigma_\varepsilon = 0.012$. Also, $\rho = 0.93$ is taken from the yearly Solow residual for the USA economy.

5 Results

The model has been simulated for 29 periods (same as for our empirical evidence). The results are reported in Table 2. The first column is the actual data for the USA, the second column is the model with a wage premium of 2 and the third column reports results for the model economy without the underground economy sector.

Table 2. Computation results. Standard deviations

	USA	(wp=2)	(No Und.)
Participation rate (mean)	0.660	0.660	0.660
Registered output	0.0365	0.0365	0.0365
Consumption	0.0320	0.0267	0.0258
Investment	0.0730	0.0750	0.0780
Participation rate	0.0176	0.0185	0.0152

The benchmark model, calibrated to match an average participation rate of 66% and the standard deviation of registered output (3.65%), reproduces the key features observed in the data. The model generates fluctuations in investment of 7.5% (as compared to 7.3% in the USA). The fluctuation in consumption is 2.67%, below that of the USA, 3.2%. Finally, the participation rate would have a standard deviation implied by the model of 1.85%, as compared to 1.76% in the USA economy.

The exercise performed implies that any person belonging to the working age population, but not employed in the registered economy, will work an average of 0.024 hours in underground activities (compared to the one third corresponding to workers in registered activities). Finally, we indirectly get an estimate of the size of the underground economy (measured by underground activities output over registered output) of roughly 3.2%.

In order to assess to what extent our model helps understand the empirical facts, we recompute the model for the case when we abstract from the existence of underground economy. Given the same parametrization, if the underground economy sector is not present, the participation rate would be higher, 71% as compared to the observed 66%, and the standard deviation of registered output would be 3.18% (13% smaller). In order to compare the relative performance of the model with and without an underground economy sector, we now recalibrate the parameters A and σ_ε in the model without underground economy in order to match the observed average participation rate and the standard deviation of output. As Table 2 shows, the model without an underground economy sector performs worse in matching the empirical facts regarding fluctuations in consumption, investment and participation rates.

6 Effects of a decrease in the wage premium

The next exercise is to determine the extent to which exogenous changes in the wage premium can account for the differences in fluctuations observed between the USA and European economies. We will analyze how economies that only differ in their wage premium will react to the same technological shocks.

Therefore, we keep the same parameters (except for the constant B) and technological shocks used to calibrate the USA economy. A smaller wage premium will induce a smaller participation rate, since the opportunity cost of not participating in registered activities decreases. Then, with more population out of the registered economy, the effects of technological shocks are amplified. In response to every shock in the registered economy, more population will be getting in (or out) of it. As a result, economies only differing in their wage premiums would perform differently when subject to the same technological shocks.

Dolado et al. (1996) provide values for the wage premium in the USA and most European countries. They report a 1993 value of 2.56 for the USA.[5] For the European countries included in our European aggregate, the data belong to

[5] Notice that in Mankiw et al. (1992), the wage premium takes a value of 2, since it is an average for the period 1960 to 1990. This value seems to be consistent with the 2.56 for 1993 provided by Dolado et al. (1996), since the USA wage premium has increased substantially during the eighties and the nineties.

different years in the early nineties, and their average is around a value of 2. Our exercise, therefore, consists in calibrating the constant B for a wage premium of 1.6 (20% smaller than the one in the benchmark case). The results and their comparison to the actual European data are reported in Table 3.

Table 3. Computation results. Standard deviations

	EU	(wp=1.6)
Participation rate (mean)	0.622	0.605
Registered output	0.0514	0.0431
Consumption	0.0510	0.0325
Investment	0.0910	0.0859
Participation rate	0.0185	0.0264

Notice how the participation rate reduces to 60.5% (compared to the 66% implied for our benchmark economy), inducing registered fluctuations to go up to 4.31% (3.65% for the benchmark case). Time spent working for those who are engaged in underground activities doubles. This, together with a higher fraction of the population engaged in underground activities, induces the size of the underground economy to go up to 7.04% of registered output. Also, the standard deviation of investment goes up to 8.59%. The reason is that when more population moves in and out of the registered sector in response to technological shocks, investment moves in the same direction. Finally, a smaller wage premium implies higher fluctuations of the participation rate.

We turn now to compare the behavior of the model economy if the wage premium is 1.6 with the European facts. The effects go in the right direction, although their size differs along some dimensions with the data. There is an increase in aggregate fluctuations, even though it cannot account for the European standard deviation of GDP (4.31% in the model economy vs. 5.14% in the European data) and the participation rate decreases more than observed in the European data (60.5% in the model economy vs. 62.2% for Europe). Also, the standard deviation of the model participation rate increases beyond that observed in the European data (2.64% in the model vs. 1.85% for Europe). On the other hand, the European fluctuations of investment and consumption are 9.10% and 5.10%, respectively, compared to 8.59% and 3.25% for the model economy.

Therefore, differences in the wage premium alone, as observed in the data, can account for 44.3% of the observed differences in fluctuations between the USA and Europe. Hence, even though the existence of underground economy might be important in explaining this difference, we cannot conclude that this is the only factor generating it. Finally, it is remarkable how introducing an underground economy sector increases the fluctuations of investment in an order of magnitude similar to that observed in the actual data. However, changes of the wage premium in the model generate effects on participation rates, both in terms of mean and standard deviation, that go beyond the differences observed in the data.

Regarding the size of the underground economy implied by the model (3.2% of registered output for a wage premium of 2 and 7% for a wage premium of 1.6), our results are in the range of those found in the literature. In particular, Pissarides and Weber (1989), using a procedure based on discrepancies between registered consumption and reported self-employed income, report a size of the underground British economy of 5.5% of GDP. A survey of estimates for European countries and the USA based on different methodologies can be found in Marrelli (1987). Using also a discrepancy approach, he reports estimates of 4.5% for the USA, 5 to 9% for Germany or 11% for Belgium.

This exercise shows how the model is able to reproduce the facts presented in Section 2. A smaller wage premium (in this case 20% smaller) induces a decrease in the participation in registered activities. Then, there will be a higher fraction of working-age population outside the registered economy and, in response to exactly the same shocks, we will find more movement in and out of the labor force, so that fluctuations of the registered economy will be higher. At the same time, the size of the underground economy as a fraction of registered output would be larger.

7 Conclusions

This paper explores the role of underground economic activities in explaining differences in registered aggregate fluctuations. In our empirical analysis, we find that at low frequencies Europe fluctuates more than the USA, while its participation rate is smaller. We introduce an underground economy sector in an otherwise standard Real Business Cycle model and calibrate it to the USA economy, generating a negative relationship between participation rates and fluctuations. In the standard RBC model, fluctuations do not depend on the level of the participation rate. In our framework, an economy with a smaller participation rate will have a larger underground economy sector and larger fluctuations in registered economic activities.

Our model shows how a wage premium 20% smaller (the difference observed between Europe and the USA) generates a smaller participation rate and larger fluctuations of the registered economy, accounting for 44.3% of the differences in aggregate fluctuations between the USA and European economies. However, the changes that are predicted by the model economy regarding mean and standard deviation of participation rates are bigger than the differences observed in the data.

Finally, the model generates implied sizes of the underground economy of 3.2% and 7% of the American and European registered output, respectively, which are in the range of those found in the empirical literature.

In our model economy, the wage premium can be interpreted as an exogenously given indicator of all the fiscal and welfare policies. Also, we are abstracting here from the problem of the illegality of underground activities. The individuals involved in them are usually incurring in the risk of being charged for violation of tax evasion laws. A next step for further research should be to explicitly introduce different fiscal and welfare policy instruments in the analysis.

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