Aggregate Employment Fluctuations and Agricultural Share[†]

José María Da Rocha

Universidad Carlos III de Madrid

and Universidade de Vigo

Diego Restuccia

University of Toronto

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Abstract

Differences in employment volatility and the correlation of employment with output across countries are often cited as examples of the limitation of standard real business cycle (RBC) theory to reproduce the observed labor market facts. These observations have lead researchers to argue for the necessity of Non-Walrasian features to reflect the labor institutions in European countries. In this paper, we show that the same labor market evidence is observed in regional economies with the same labor market institutions. We conjecture that differences in agricultural activity can generate the observed differences in labor market behavior. We show that a standard two-sector RBC model with agriculture and non-agriculture can account for the observed labor market facts. In particular, as the size of agricultural activity increases, aggregate employment volatility and the correlation between aggregate employment and output decrease. Moreover, contrary to the Non-Walrasian approach to business cycles, agricultural activity can account for the correlation between aggregate employment and output as reported by Danthine and Donaldson (1993) for Europe and the U.S.

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1 Introduction

Differences in employment volatility between European countries and the U.S. are often cited as evidence of the importance of labor market institutions in accounting for labor market fluctuations in Europe.[1] Moreover, the low correlation of employment with output in Europe (as the values registered in Portugal and Greece), is emphasized as a limitation of standard real business cycle (RBC) theory to reproduce the European labor market facts.[2] In fact, Danthine and Donaldson (1993) conclude that in order to account for the European labor market behavior is necessary to introduce market imperfections, bargaining, and other institutional characteristics of the European environment. There seems to be a consensus expressed in Maffezzoli's (2001) writing, "The RBC literature has focused on purely competitive models, designed to fit the U.S. institutional framework... institutional differences, mostly evident in the labor market, suggest that a Walrasian model may be inappropriate for the study of business cycles in Europe."

This has lead to an important line of research that introduces Non-Walrasian labor markets in dynamic general equilibrium economies in order to account for the European labor market facts (see Danthine and Donaldson, 1995). Recently, Maffezzoli (2001) explores the role of non-competitive labor markets in Italy and is successful in accounting for the difference in employment volatility between Italy and U.S., but even with monopolistic competition in the labor market the model cannot account for the low correlation between aggregate employment and output in Italy.

However, if labor business cycle differences observed across European countries are also observed across regions of the same country, then labor market institutions cannot be relied upon. In this paper, we show that the differences observed in employment fluctuations between Spanish regions are quantitatively similar to those observed between European countries and the U.S. Therefore, dimensions other than labor institutions can be important in accounting for the differences observed in aggregate labor market facts.

We argue that a standard two-sector RBC model with agriculture and non-agriculture can account for the differential pattern observed in aggregate labor markets. The reason this particular disaggregation of the standard RBC model works is that agriculture behaves very differently over the cycle than the rest of the economy: its employment and output are

[1] Business cycle statistics for Europe are reported by Danthine and Donaldson (1993) and Kollintzas and Fiorito (1994).

[2] For RBC models of Greece and Portugal, see Correia, Neves and Rebelo (1995) and Kollintzas and Vassilatos (1996) respectively.

not pro-cyclical.[3] These facts lead us to conclude that aggregate business cycle implications depend critically on the size of the agricultural sector in the economy. Our conjecture is that agriculture acts as a buffer to shocks in the economy.[4] The advantage of our theory is that the dimension in which we compare different economies, namely the share of agricultural activity, is well defined and measured in the data, and its implications for business cycle statistics can be contrasted with data.

In order to isolate the role of the agricultural share from the role of labor market institutions, we study the effects of agriculture within regions of the same country, in this case Spain. Among the 17 regions of Spain, Galicia presents similar levels of agricultural activity as in Portugal and Greece (the output share is 0.09 in Galicia and 0.13 and 0.07 in Greece and Portugal respectively). Also, among the 17 regions in Spain, Galicia presents the highest employment rate in agriculture (9% in Galicia versus 5% in Spain). We first show that: (1) relative to output variability, aggregate employment fluctuates less in Galicia than in Spain and, (2) the correlation between aggregate employment and output is lower in Galicia than in Spain. Second, we show that both in Galicia and Spain, agricultural activity presents the properties identified for OECD countries documented in Da-Rocha and Restuccia (2002). That is, between Galicia and Spain, we observe the same labor market business cycle differences reported by Danthine and Donaldson (1993) between Europe and the U.S.

To illustrate how well standard theory can generate the observed business cycle differences when comparing artificial economies that only differ in the size of agricultural sector, we follow Benhabib, Rogerson, and Wright (1991) in considering a two-sector model with agriculture and non-agriculture. We only depart from this basic framework in that we introduce lotteries, as in Rogerson (1988), to write the problem in terms of employment shares in each sector in order to compare the statistics of the model with available data.

We calibrate the model to match the Galician agricultural output and employment shares. As an experiment, we modify parameters pertaining to the non-agriculture technology to reproduce employment and output shares of agriculture in economic activity in Spain. We find that, as the share of the agricultural sector in the economy increases, ag-

[3]Da-Rocha and Restuccia (2002) document in a sample of OECD countries, that the counter-cyclical properties of agricultural activity are present even in developed countries such as the U.S. where the agricultural share in the economy is not large.

[4]This role of agriculture during recessions and booms has been documented in the past, but never analyzed in the context of a real business cycle model. Rozelle, Zhang, and Huang (2001) document the negative correlation between non-farm employment and farm employment in rural China and Lee (1980) reports similar features of agricultural employment in Korea.

gregate employment fluctuates less and is less correlated with aggregate output. The main implication of the results is that as the share of agriculture in the economy declines, differences in observed business cycle fluctuations, whether across regions or countries, would decline as well.

The paper proceeds as follows. Section 2, documents evidence across regions in Spain. Section 3 describes the model, defines equilibrium, and presents the main equations characterizing the steady state equilibrium of the deterministic version of the model. In section 4, we describe the computational experiment, the calibration procedure, and the results. Section 5 concludes.

2 Real Business Cycle Facts

Cross-country evidence, specially between Europe and the U.S., has been used to argue that the standard RBC model with competitive labor markets cannot be applied to understand European business cycles, leading naturally to a line of research of business cycles with non-competitive labor markets. In particular, the evidence consists of two important facts about business cycle differences between Europe and the U.S. First, European employment fluctuates less than U.S. employment (the same applies for employment volatility). Second, Europe registers a lower correlation of employment and output than the U.S. Danthine and Donaldson (1993) report that the employment volatility in Europe is 0.55 compared to 0.80 in the U.S. (a factor of 2/3), while the correlation of employment with output is 0.47 in Europe relative to 0.83 in the U.S. (a factor of 3/5).

In this section we emphasize three sets of observations. The first two sets call into question the need for immediate departure from the standard competitive framework by pointing to regional evidence suggesting that the same business cycle patterns of low employment volatility and correlation with output holds across economies with similar labor market institutions. The third set of observations point to evidence suggesting a role for agriculture in accounting for these disparate labor market facts.

We begin our discussion by studying employment fluctuations across regions in Spain. A striking finding emerges. There is as much employment fluctuations differences across regions in Spain as there are differences between Europe and the U.S. even though labor market and other institutional features are constant across these regions. Figure 1 documents labor market fluctuation differences of a factor of two across regions in Spain.

We now consider the main business cycle observations for Galicia and the aggregate of

Spain. Table 1 reports basic statistics for the logarithm of Hodrick-Prescott filtered data for Galicia and Spain at quarterly frequency.[5] The same finding emerges: differences between Galicia and Spain of a factor of 2/3 in aggregate employment volatility and of a factor of 3/5 in the correlation between aggregate employment and output.

As important as the cross-country business cycle fluctuations, these regional differences call for an explanation, however, institutional differences in the labor market cannot be relied upon. As suggested by the evidence in Figure 1, aggregate employment fluctuations are related to the size of agriculture in the economy. Below, we report additional business cycle observations of agricultural activity that are used in the remainder of the paper to illustrate the importance of agriculture in understanding aggregate labor market facts.

These observations are:

1. In Galicia, agricultural employment is not pro-cyclical.

2. The share of agricultural output is not pro-cyclical, both in Galicia and Spain.

3. Output and employment in the agricultural and non-agricultural sectors fluctuate more than output and employment for the aggregate economy, both in Galicia and Spain.

4. Agricultural output is not positively correlated with non-agricultural output, both in Galicia and Spain. Moreover, in Galicia, agricultural and non-agricultural employment are negatively correlated. Figure 2 shows the filtered series for each sector's employment in Galicia. The correlation between employment across sectors is -0.62.

5. With respect to non-agricultural output, agricultural output fluctuates much more in Spain than in Galicia (more than double), but agricultural employment fluctuates much less in Spain (about half), while non-agricultural employment fluctuates about the same in the two economies. This asymmetry is also present in the correlations of agricultural employment and output in Galicia and Spain.

In summary, the agricultural sector does not move together with the cycle. The counter cyclical nature of agriculture implies that for a large share of agriculture in economic activity, aggregate employment would fluctuate less and output and employment would be less correlated. Below, we consider a standard two-sector business cycle model with agriculture and non-agriculture that is able to account for these labor market observations.

[5]The data of output are from *Instituto Galego de Estadística* and *Instituto Nacional de Estadística* for Galicia and Spain respectively. The data of employment are from *Encuesta de Población Activa*. A representative literature with business cycle statistics for Spain can be found in Dolado et. al. (1993) and in Licandro and Puch (1997).

3 The Economic Environment

3.1 General Description

We follow Benhabib, Rogerson, and Wright (1991) in considering a two-sector economy of the business cycle. In our environment there are two goods, agriculture and non-agriculture. This distinction is crucial for our purpose of studying the size of agriculture in economic activity in accounting for differences in labor market business cycle fluctuations at the aggregate level.

Technologies: Output in each sector is produced with a constant returns to scale production function that requires labor and physical capital services as inputs. Fluctuations are driven in this model by shocks to technologies. At each date, actual output in each sector is given by

$$Y_n = \gamma^t \lambda_n e^{z_{n,t}} K_n^{\theta} H_n^{1-\theta},$$

$$Y_a = \gamma^t \lambda_a e^{z_{a,t}} K_a^{\mu} H_a^{1-\mu},$$

where, for each sector, $i \in \{a, n\}$ (where a is agriculture and n non-agriculture), K_i is physical capital input, H_i is labor input, and λ_i is a time invariant sector specific productivity. Productivity grows at an exogenous rate $\gamma \geq 1$ in both sectors and z follows a vector auto-regressive process described by

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

where $z = [z_n, z_a]'$ and ε is normally distributed with mean zero and variance-covariance matrix Ω.

Population and preferences: The economy is populated by a measure of identical households that grows over time at an exogenous rate η. We normalize the initial population measure to one. The representative household has preferences over sequences of per-capita consumption, $\frac{C_t}{L_t}$ and leisure l_t for each member of the household, described by

$$\sum_{t=0}^{\infty} \beta^t u\left(\frac{C_t}{L_t}, l_t\right) L_t,$$

where β is the time discount factor. The per-period utility function is defined as

$$u\left(\frac{C_t}{L_t}, l_t\right) = b \log\left(\frac{C_t}{L_t}\right) + (1-b) \log l_t,$$

and aggregate consumption as

$$C_t = \left[aC^e_{n,t} + (1-a)C^e_{a,t}\right]^{\frac{1}{e}},$$

Each member of the household is endowed with one unit of time each period. We assume there is indivisibility in labor hours. A household works in either sector a determined number of hours or does not work. Because the commodity space is not convex with this restriction, we introduce lotteries as in Rogerson (1988). Hansen (1985) introduces Rogerson's lotteries in a dynamic real business cycle model. With probability π^n_t, the household works $\bar{h}_n$ hours in the non agricultural sector, with probability π^a_t the household works $\bar{h}_a$ hours in the agricultural sector, and with probability $(1-\pi_a-\pi_n)$ the household does not work. This feature allows us to write the problem in terms of employment shares in each sector, since in equilibrium, π^n_t is the share of the labor force in the non-agricultural sector, π^a_t is the share of the agricultural sector, and finally, $(1-\pi^n_t-\pi^a_t)$ is the unemployment rate.

Feasibility: Non-agricultural output can be allocated to non-agricultural consumption and investment in physical capital

$$C_{n,t} + X_t \leq Y_{n,t},$$

where C_n is aggregate non-agricultural consumption, and X is aggregate investment in physical capital that follows a standard accumulation equation

$$K_{t+1} = (1-\delta)K_t + X_t.$$

Agricultural output can only be consumed

$$C_{a,t} \leq Y_{a,t},$$

where C_a is aggregate agricultural consumption. At each date, the capital stock can be allocated to either sector

$$K_{n,t} + K_{a,t} \leq K_t.$$

3.2 Definition of Equilibrium

It is convenient to write the problem in efficient units of labor, that is, all variables are divided by the population size and the exogenous productivity growth γ, and denote these variables with lower case letters. Because there are no externalities or distortions and the choice set with lotteries is convex, we think of a benevolent social planner determining allocations.

An equilibrium in this environment is a sequence of history contingent allocations

$$\{y_{a,t}, y_{n,t}, c_{a,t}, c_{n,t}, k_{t+1}, k_{a,t}, \pi_{a,t}, \pi_{n,t}\}_{t=0}^{\infty},$$

that solves the following stochastic planning problem,

$$\max E_0 \sum_{t=0}^{\infty} \widehat{\beta}^t \left\{ \frac{b}{e} \log \left[a c_{n,t}^e + (1-a) c_{a,t}^e \right] + (1-b) \left[\pi_t^n \log(1-\bar{h}_n) + \pi_t^a \log(1-\bar{h}_a) \right] \right\}$$

subject to:

$$y_{n,t} = \lambda_n e^{z_{n,t}} {k_{n,t}}^{\theta} (\pi_t^n \bar{h}_n)^{1-\theta},$$

$$y_{a,t} = \lambda_a e^{z_{a,t}} {k_{a,t}}^{\mu} (\pi_t^a \bar{h}_a)^{1-\mu},$$

$$k_t = k_{n,t} + k_{a,t},$$

$$c_{n,t} + \eta\gamma k_{t+1} - (1-\delta) k_t = y_{n,t},$$

$$c_{a,t} = y_{a,t},$$

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

where γ and η are the gross rates of productivity and population, and $\widehat{\beta} = \beta\eta$.

In our environment with $\varepsilon_t = 0$ and $z_t = 0$ for all t, a steady state equilibrium is given by a constant sequence of allocations with numbers given by the set

$$\{y_a, y_n, c_a, c_n, k_a, k_n, \pi_a, \pi_n\}.$$

3.3 Characterization

In our economy without uncertainty, there are eight equilibrium conditions that characterize the steady state:

$$k_n = \left[\frac{\xi + \delta}{\theta \lambda_n} \right]^{\frac{1}{\theta - 1}} \pi_n \bar{h}_n, \tag{1}$$

$$\frac{a}{1-a} \frac{c_n^{e-1}}{c_a^{e-1}} = \frac{\mu (y_a / k_a)}{\theta (y_n / k_n)}, \tag{2}$$

$$\frac{b}{1-b} + \frac{\pi_n \log(1-\bar{h}_n)}{(1-\theta)y_n} \frac{ac_n^e + (1-a)c_a^e}{ac_n^{e-1}} = 0, \tag{3}$$

$$\frac{b}{1-b} + \frac{\pi_a \log(1-\bar{h}_a)}{(1-\mu)y_a} \frac{ac_n^e + (1-a)c_a^e}{(1-a)c_a^{e-1}} = 0, \tag{4}$$

$$c_{n,t} + (\eta\gamma + \delta - 1)(k_n + k_a) = y_n, \tag{5}$$

$$c_{a,t} = y_a, \tag{6}$$

$$y_n = \lambda_n e^{z_{n,t}} {k_{n,t}}^{\theta} (\pi_{n,t}\bar{h}_n)^{1-\theta}, \tag{7}$$

$$y_a = \lambda_a e^{z_{a,t}} {k_{a,t}}^{\mu} (\pi_{a,t}\bar{h}_a)^{1-\mu}, \tag{8}$$

where $\xi = \frac{\eta\gamma}{\widehat{\beta}} - 1$, $\Phi_i = -\frac{\log(1-\bar{h}_i)}{\bar{h}_i}$, $h_i = \pi_i \bar{h}_i$ for $i \in \{n, a\}$. These equations are fairly intuitive. Equation (1) is the Euler condition for capital accumulation. Equation (2) relates the marginal returns of capital allocated to agriculture and non-agriculture with the marginal utility from each good. Equations (3) and (4) relate to the static choice between consumption of agricultural and non-agricultural goods and leisure, finally, (5) and (6) are the resource constraints and (7) and (8) are the two production functions. Equations (1) to (8) define a system of 8 equations in 8 unknowns $\{y_a, y_n, c_a, c_n, \pi_a, \pi_n, k_a, k_n\}$, that is used to solve for the steady state.

In order to calibrate the model, it is useful to substitute equation (1) into (2) to obtain

$$k_a + k_n = \left[1 + \frac{\mu(1-\theta)\pi^a}{\theta(1-\mu)\pi^n} \frac{log(1-\bar{h}_a)}{log(1-\bar{h}_n)}\right] \left[\frac{\xi + \delta}{\theta\lambda_n}\right]^{\frac{1}{\theta-1}} \pi^n \bar{h}_n, \tag{9}$$

and define the aggregate work hours

$$h_T = \pi^n \bar{h}_n + \pi^a \bar{h}_a, \tag{10}$$

and the share of agriculture in aggregate output in the economy, s_a as

$$s_a = \frac{p_a y_a}{p_a y_a + y_n}, \tag{11}$$

where p_a is the price of the agricultural good in terms of the non-agricultural good given by

$$p_a = \frac{u_{c_n}}{u_{c_a}},$$

where u_{c_i} is the marginal utility from consumption of good i. In this economy, the aggregate capital income share can be computed as

$$\alpha = s_a\mu + (1 - s_a)\theta. \tag{12}$$

4 Quantitative Experiment

We restrict our theory to match observations characterizing the Galician economy. The quantitative experiments that follow are designed to answer a specific question: can the share of agriculture in economic activity account for the differential pattern in economic fluctuations between an agricultural intensive economy such as Galicia, and a less agricultural economy such as Spain and the U.S.? The experiments involve modifying parameters of output technologies to roughly match lower agricultural shares than in the benchmark economy. We emphasize that preference parameters and the stochastic process of technology shocks are kept the same across experiments in order to isolate the role of agriculture in business cycles.

4.1 Calibration

We assign parameter values of the benchmark economy to match relevant statistics for the Galician economy. There are three main components in our procedure. First, we find a set of parameter values for an aggregate economy using aggregate data for Galicia. Second, we use these calibrated parameters and equilibrium equations from our two-sector economy to find an additional set of parameters, using sectoral data for Galicia. Of key importance are parameters pertaining to the two technologies. Finally, we calibrate the parameters defining the stochastic component of the environment.

The length of a period is assumed to be one quarter. In the appendix we describe in detail a standard aggregate economy from which we calculate the depreciation rate δ, aggregate TFP λ, and the discount rate $\beta(\alpha)$, by using the steady state equilibrium equations and data on the net and gross investment rates. Note that β depends on the capital income share of the aggregate economy α. This object is calculated in the second step of our calibration procedure. An alternative strategy would be to use a net interest rate to calibrate β, however using aggregate data to calibrate this parameter is not an appropriate strategy in the context of our model given the importance of agricultural production in Galicia and the importance of self-employment in agriculture.

We assume that productivity in each sector λ_i, is equal to the aggregate of the economy,

$\lambda_a = \lambda_n = \lambda$[6]. Aggregate work hours h_T is assumed to be 1/3 as in Hansen (1985).

Data is used to calculate the following objects: θ as the capital income share in non-agriculture, s_a as the share value of agricultural output, π_a as the employment rate in agriculture, and π_n as the employment rate in non-agriculture, as described in the appendix. There are 5 parameters remaining: $\bar{h}_n$, $\bar{h}_a$, a, b, and μ. We use the following algorithm to find these values: given a guess of μ, we obtain α using equation (12), the remaining 4 parameters are calculated using equations (9), (10), (3), and (4). Finally, equation (11) gives a share s_a for the calibrated model. If this value is higher or lower than the observed in the data, our guess of μ is adjusted until the algorithm converges.

Calibrated parameters are presented in Table 2. Most parameter values are reasonable compared to calibrated values for the U.S. economy. An important characteristic of the parameter values is that labor hours and capital intensity are higher in the non-agricultural sector, with hours of work in the non-agricultural sector being near the 0.5 result of Hansen (1985).

We calibrate the stochastic process describing technology shocks as follows. We use data for non-agriculture to calculate the solow residual and estimate the persistence ρ_n and standard deviation of the shock σ_{ε_n}. We assume the same persistence and standard deviation for the agricultural shock and assume zero cross-persistence. The correlation of the error terms $corr(\varepsilon_n, \varepsilon_a)$ is chosen to reproduce the correlation between aggregate employment and output (0.49). Therefore, the auto-correlation and variance-covariance matrices are given by

$$\rho = \begin{bmatrix} 0.9 & 0.0 \\ 0.0 & 0.9 \end{bmatrix}, \quad \Omega = \begin{bmatrix} 0.00858^2 & cov(\varepsilon_n, \varepsilon_a) \\ cov(\varepsilon_n, \varepsilon_a) & 0.00858^2 \end{bmatrix},$$

where $cov(\varepsilon_n, \varepsilon_a)$ is the correlation of the error terms times the product of the standard deviations. Finally, we choose the parameter dictating the substitution in consumption of agricultural and non-agricultural goods e, in order to reproduce the relative volatility of agricultural output share (2.33). In the appendix, we evaluate the sensitivity of the results of the benchmark economy for different values of the elasticity of substitution across goods e, the correlation of innovations of the shocks $corr(\varepsilon_n, \varepsilon_a)$, and the relative volatilities of shocks $\sigma_{\varepsilon_a}/\sigma_{\varepsilon_n}$.

[6]Decisions related to capital and labor allocations depend on differences in the physical capital intensity and work hours in each technology. This latter effect is indistinguishable from productivity differences as specified in the model.

4.2 Quantitative Implications

We simulate the benchmark economy and compare relevant statistics from the simulated economy with actual data. Then we modify parameters pertaining to the non-agricultural technology in order to generate a steady state economies with low shares of agriculture in economic activity.

The Benchmark Economy. The model is computed using a Linear Quadratic method described in detail in McGrattan (1990). We report results for 1,000 simulations of the benchmark economy in Table 3. All statistics reported for the model are filtered using the same procedure for the data. Several interesting findings emerge. The model generates volatilities and correlations with output of all variables that are consistent with the data. In particular, in the model agricultural employment and output are negatively correlated with non-agricultural output, as observed in the data. In the model, aggregate employment and aggregate output fluctuate less than sectoral employment and output respectively, as observed in the data. In summary, we argue the model is able to capture the main cyclical patterns of an agricultural intensive economy (Galicia).

Quantitative Experiments. From the benchmark economy, we change the capital income share in non-agriculture θ, working hours in non-agriculture $\bar{h}_n$, and aggregate total factor productivity λ to roughly reproduce an economy with lower agricultural activity, in particular, we restrict the deterministic steady state of the model to reproduce an output share of agriculture s_a, an employment rate in agriculture π^a, and an employment rate in non-agriculture π^n that are similar to observations from Spain. Values of the parameters for this experiment are reported in Table 4. We refer to this exercise as Experiment 1.

The model is simulated using the new parameter values. Results are reported in Table 5 along with the statistics for the benchmark economy. Several properties of the experiment are worth noting. Experiment 1 produces a higher employment volatility than the benchmark economy and a correlation between aggregate output and employment that is much higher than in the benchmark economy (0.88 vs. 0.49). The experiment generates a difference relative to the benchmark economy in the correlation of employment and output of a factor of 3/5 as observed between Europe and the U.S. As with the results from the benchmark economy, aggregate output and employment fluctuate less than the sectoral components.

In Experiment 2, relative to the parameters in Experiment 1, we change total factor productivity in the agricultural sector. The steady state of the model generates values for the output and employment share of agriculture that resemble the observed for the U.S., as reported in Table 4. Results of this exercise are reported as Experiment 2 in Table 5. Both aggregate employment volatility and the correlation of employment with output are higher than in Experiment 1. This experiment generates differences in employment volatility with respect to the benchmark economy of a factor of 2/3 (0.85 vs. 0.66).

We emphasize that preference and technology shocks are all the same across experiments, only output technology parameters are changed. Since these parameters affect the size of the agricultural sector, the experiments isolate the role of this feature in aggregate fluctuation differences between an agricultural intensive economy, such as Galicia, and a less agricultural intensive economy, such as Spain.

In summary, differences in the agricultural size, as those observed between European countries (see Da Rocha and Restuccia, 2002) can generate differences in aggregate labor market volatilities as those observed in the data. Moreover, the role of agriculture accounts for the low correlation of employment and output as those observed in the data. None of the implications of our theory depend on major departures of the standard competitive framework and the implications of the theory are consistent with both cross-country and regional business cycle observations.

5 Conclusions

The main contribution of this paper is to show that the evidence typically used to reject the standard RBC model as applied to European business cycles, is also present in regional economies with the same labor institutions. This evidence calls into question an immediate departure of the competitive framework associated with the standard model.

We conjecture a theory based on a measurable and well defined hypothesis: the size of the agricultural sector. Moreover, the implications of agriculture in business cycles can be contrasted against data. Our results indicate that a particular disaggregation of the standard RBC model can generate the business cycle differences in labor markets similar to those observed between European countries and the U.S. These results come from a natural decomposition of the standard stochastic neoclassical growth model with agriculture and non-agriculture.

Our quantitative experiments show how changes in the relative size of agriculture can generate economies with lower employment volatilities. Moreover, contrary to the Non-Walrasian approach to business cycles, differences in agricultural activity can generate differences in the correlation between aggregate employment and output as large as those reported by Danthine and Donaldson (1993) between Europe and the U.S.

A Calibration

A.1 A Standard Aggregate Economy

Consider a neoclassical growth economy without leisure. Households have preferences over consumption streams and discount the future at the rate β. There is only one good that is produced with a standard constant returns to scale technology

$$Y_t = \lambda A_t K_t^{\alpha} H_t^{1-\alpha},$$

where K_t is physical capital input, H_t is labor input measured in hours, and λA_t is total factor productivity. We define the labor input as hours per person times the population size, $H_t = N_t h$ and h is time invariant. There is exogenous growth in both productivity and population size: $A_t = \gamma^t$ and $N_t = \eta^t$.

It is convenient to define all variables in per-effective units of labor, i.e. any variable X is transformed into $x_t = \frac{X_t}{A_t N_t}$. Therefore

$$y_t = \lambda k_t^{\alpha} h^{1-\alpha}.$$

A steady state for this economy is characterized by exogenous growth. Y and K grow at the rate $\gamma\eta$ and y and k are stationary.

From this economy, λ and h are a normalization of output units[7]. We are interested in finding values for δ and β of this aggregate economy. We calculate a quarterly growth rate for population and per-worker growth as η and γ. We use the following data: (1) net capital formation over GDP, and (2) depreciated capital over GDP. The mapping between these observations and the model is as follows, the left hand side refers to the data, and the right hands side to the model:

$$data(1) = (\eta\gamma - 1)\frac{k}{y}, \tag{13}$$

$$data(2) = \delta\frac{k}{y}. \tag{14}$$

We apply the following algorithm to find the parameter values: (a) Given values for η, γ, and data(1), the first equation implies a value for the capital-output ratio, $\frac{k}{y}$. From the second

[7] We normalize $h = 1$ and λ to match the average per effective output for Galicia.

equation, using data(2) and the computed $\frac{k}{y}$ we obtain δ as

$$\delta = \frac{data(2)}{\frac{k}{y}}.$$

(b) Given δ, γ, η, and $\frac{k}{y}$, we use the euler equation for capital accumulation in steady state to obtain $\hat{\beta}$

$$\hat{\beta} = \frac{\gamma\eta}{\alpha\frac{y}{k} + (1-\delta)},$$

as a function of the aggregate capital share α. With a log per-period utility, $\beta = \frac{\hat{\beta}}{\eta}$.

The data used in this procedure for Galicia is given in the following table:

Parameters	**Galicia**
η (quarterly)	0.9977
γ (quarterly)	1.0066
data(1)	0.07
data(2)	0.11

As we explain in detail in the calibration section, α is a weighted average of the capital income shares in the agricultural and non-agricultural sectors.

A.2 Calibration of θ and values for s_a, π^a, and π^n

To calibrate θ, we obtain the average wage in the economy (for the period 1976-1991) and obtain total compensation of employees in the non-agricultural sector using the output share in non-agriculture. The share of agriculture s_a is calculated as an average over the period. The following table presents the results of these calculations:

	s_a	θ
Galicia	0.10	0.36
Spain	0.05	0.38

We calculate π^a and π^n as an average of the proportion of workers in each sector relative to the total labor force

$$\pi^a = \frac{1}{16}\sum_{t=1976}^{1991}\left(\frac{L_t^a}{N_t}\right),$$

$$\pi^n = \frac{1}{16}\sum_{t=1976}^{1991}\left(\frac{L_t - L_t^a}{N_t}\right),$$

where aggregate employment is $L_t = L_t^n + L_t^a$ and total labor force $N_t = L_t + U_t$. The following table presents the results of these calculations for Galicia and Spain:

	π^a	π^n	$1 - \pi^a - \pi^n$
Galicia	0.38	0.53	0.09
Spain	0.14	0.71	0.15

The calibration procedure described in the text finds parameter values such that in the steady state of the model, s_a, π^a, and π^n match as close as possible the calculated values from the data for Galicia.

B Sensitivity Analysis

Table 6 reports the results of the benchmark economy for different values of the parameter governing the elasticity of substitution between the agricultural and non-agricultural goods e. Given the stochastic structure of the shocks, a low e generates very little volatility of the agricultural sector relative to the data.

Table 7 explores results of the benchmark economy for different values for the correlation of shocks $corr(\varepsilon_a, \varepsilon_n)$. A correlation of 1/2, generates results for the model with a correlation between output and employment as observed in the data.

We report simulations of the benchmark model with different assumptions regarding the volatility of TFP in each sector (our benchmark calibration assumes the same for both sectors). Table 8 considers a standard deviation of the agricultural shock that is 1, 2, 5, 10, 20 times the standard deviation of the shock in the non-agricultural sector. As is evident from the table, higher exogenous volatility in the agricultural sector would require lower elasticity of substitution across goods in order to reproduce the volatility in agricultural activities observed in the data.

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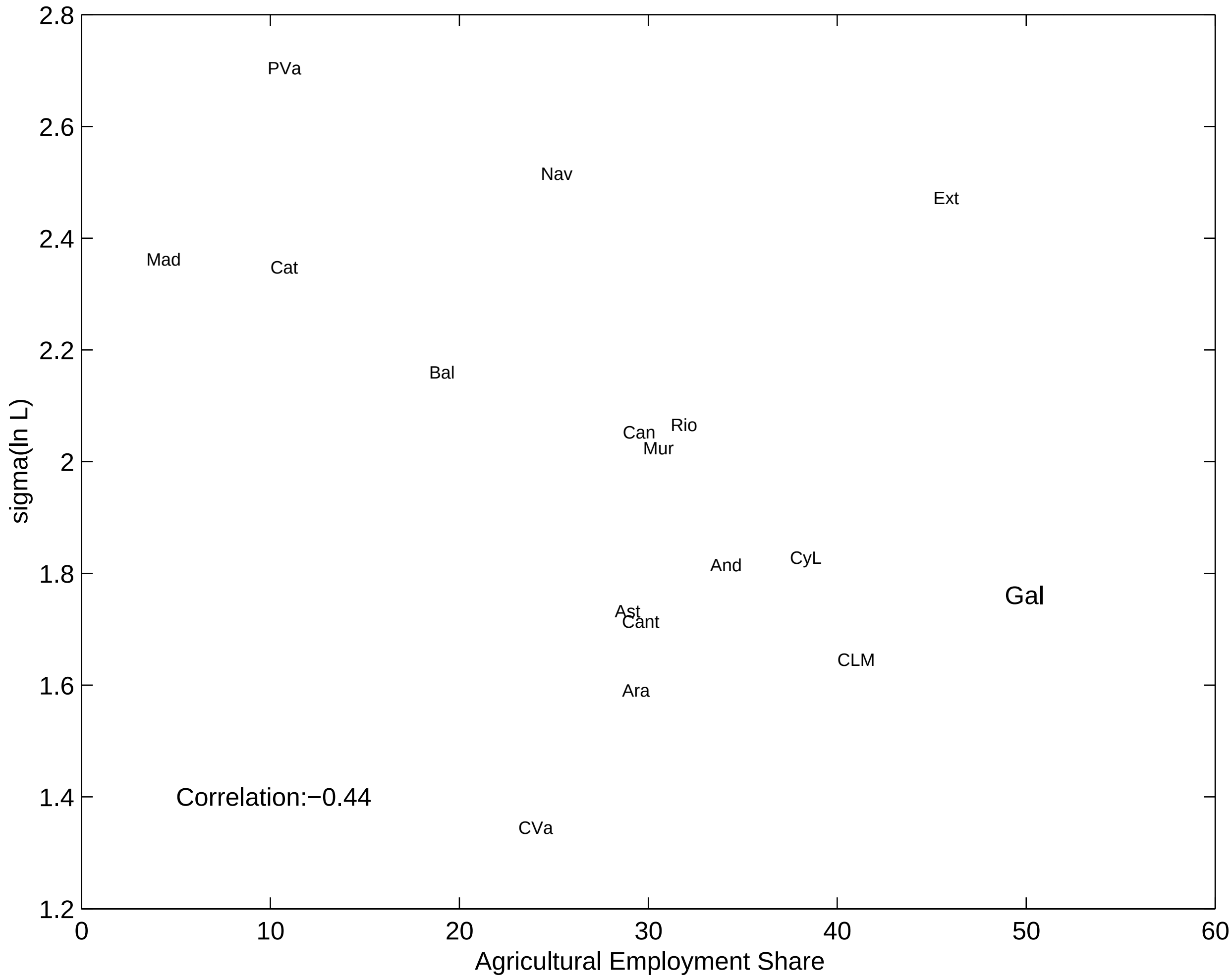
Figure 1: Employment Fluctuations for Regions in Spain (1955-1995)



And = Andalucía; Ara = Aragón ; Ast = Asturias; Bal = Baleares; Can = Islas Canarias; Cant = Cantabria; CyL = Castilla y León; CLM = Castilla La Mancha; Cat = Cataluña; Cva = Comunidad Valenciana; Ext = Extremadura; Gal = Galicia; Mad = Madrid; Mur =Murcia; Nav =Navarra; PVa = País Vasco; Rio = La Rioja.

Figure 2: Employment Fluctuations in Galicia

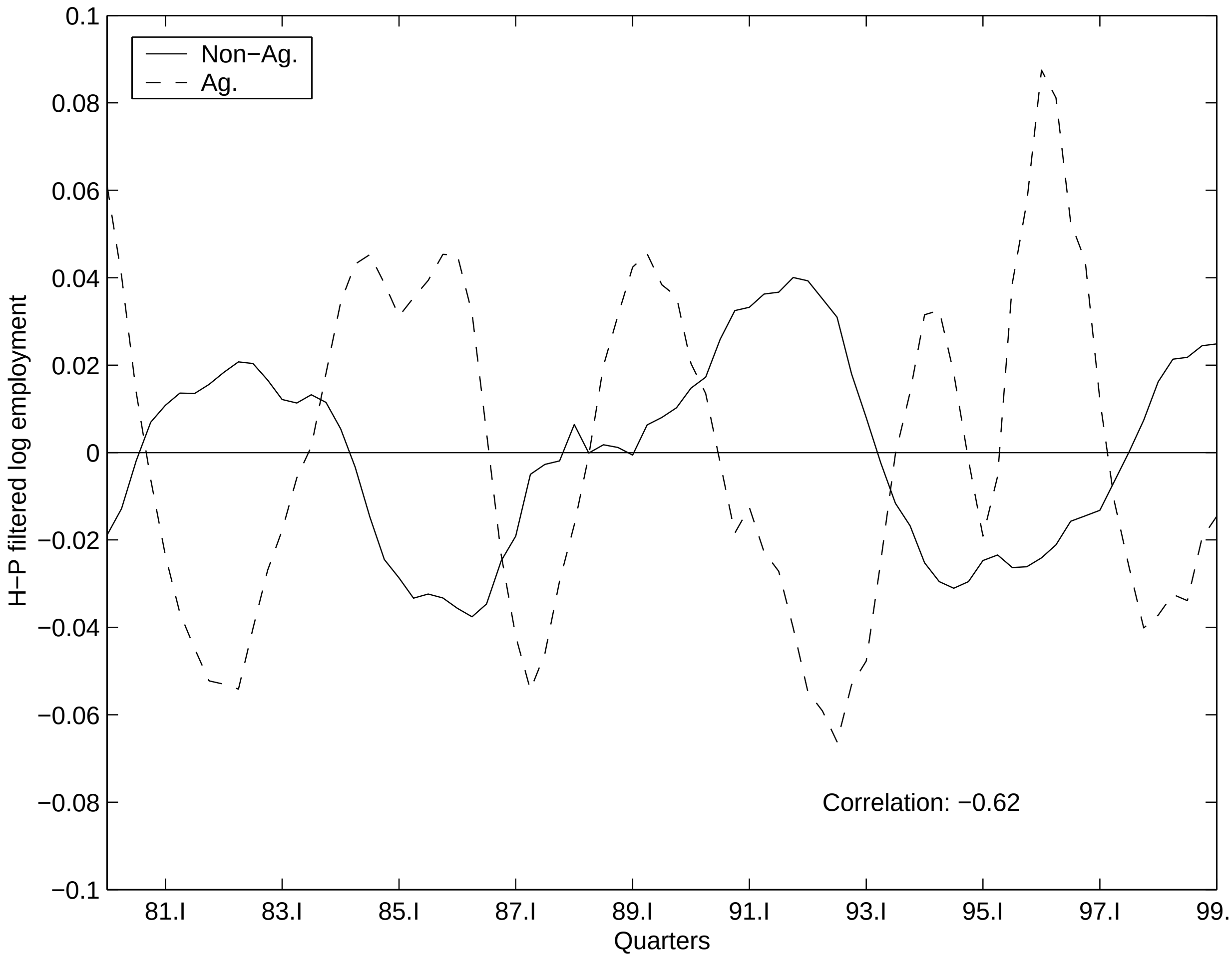


Table 1: Basic Real Business Cycle Statistics

	Galicia			Spain		
Series(x)	σ_x	σ_x/σ_y	$\rho(x,y)$	σ_x	σ_x/σ_y	$\rho(x,y)$
Aggregate Output (y)	1.08	1.00	1.00	1.08	1.00	1.00
Aggregate Employment	1.26	1.17	0.49	1.79	1.66	0.86
Non-Ag. Employment	2.17	2.01	0.57	2.02	1.87	0.84
Ag. Employment	3.75	3.47	-0.09	1.82	1.68	0.39
Ag. Output	2.52	2.33	-0.24	5.28	4.89	-0.06
	σ_x	σ_x/σ_{y_n}	$\rho(x,y_n)$	σ_x	σ_x/σ_{y_n}	$\rho(x,y_n)$
Non-Ag. Output (y_n)	1.21	1.00	1.00	1.14	1.00	1.00
Ag. Output	2.49	2.06	-0.09	5.33	4.68	-0.12
Non-Ag. Employment	2.17	1.79	0.55	2.02	1.77	0.78
Ag. Employment	3.75	3.10	-0.16	1.82	1.60	0.31

Quarterly data (80.I/99.I) and HP filtered with $\lambda = 1600$.

Table 2: Calibrated Parameters

Parameters	Data
$h_T = 0.3333$	Hansen (1985)
$\gamma = 1.0066$	Productivity growth rate (BBVA)
$\eta = 0.9977$	Labor force growth rate (BBVA)
$\theta = 0.3632$	Non-agricultural capital share (BBVA)
$\rho_a = \rho_n = 0.9$	Solow residuals for non-agriculture (IGE, EPA)
$\sigma_{\varepsilon_a} = \sigma_{\varepsilon_n} = 0.00858$	Solow residuals for non-agriculture (IGE, EPA)
Parameters	**Targets**
$\delta = 0.0065$	Depreciated capital over GDP (BBVA), 0.11
$\lambda_a = \lambda_n = \lambda = 0.2402$	Net capital formation over GDP, 0.07
$\beta = 0.9895$	Aggregate capital share, $\alpha(\mu)$
$\bar{h}_n = 0.5368$	Employment rate in non-agriculture (BBVA), $\pi_n = 0.53$
$\bar{h}_a = 0.1276$	Employment rate in agriculture (BBVA), $\pi_a = 0.38$
$a = 0.6033$	Agricultural output share (BBVA), $s_a = 0.10$
$b = 0.3883$	Aggregate hours worked, $h_T = 1/3$
$\mu = 0.2481$	Aggregate capital share, $\alpha(\mu)$
$corr(\varepsilon_a, \varepsilon_n) = 1/2$	Employment correlation with output, $\rho(L, y) = 0.49$
$e = 0.8$	Volatility of agricultural output share, $\sigma_{s_a}/\sigma_y = 2.33$

Table 3: Business Cycles in the Benchmark Economy

	Galicia		**B.E.**	
	σ_x/σ_y	$\rho(x,y)$	σ_x/σ_y	$\rho(x,y)$
Employment	1.17	0.49	0.66	0.49
Non-Ag. Employment	2.01	0.57	1.03	0.95
Ag. Employment	3.47	-0.09	1.48	-0.31
Ag. Output Share	2.33	-0.24	1.91	-0.65
	σ_x/σ_{y_n}	$\rho(x,y_n)$	σ_x/σ_{y_n}	$\rho(x,y_n)$
Ag. Output	2.06	-0.09	1.27	-0.31
Non-Ag. Employment	1.79	0.55	0.90	0.96
Ag. Employment	3.10	-0.19	1.29	-0.43

Table 4: Parameter and Targets in Each Experiment

	Experiment 1	**Experiment 2**
Targets		
s_a	0.04	0.01
π^a	0.15	0.04
π^n	0.79	0.81
Parameters		
θ	0.38	0.38
$\bar{h}_n$	0.43	0.43
λ	0.35	$\lambda_n = 0.35,\ \lambda_a = 0.24$

Table 5: Results of Experiments

	B.E.		**Experiment 1**		**Experiment 2**	
	σ_x/σ_y	$\rho(x,y)$	σ_x/σ_y	$\rho(x,y)$	σ_x/σ_y	$\rho(x,y)$
Employment	0.66	0.49	0.71	0.88	0.85	0.96
Non-Ag. Employment	1.03	0.95	0.99	0.97	0.93	0.97
Ag. Employment	1.48	-0.31	1.98	-0.49	2.00	-0,51
Ag. Output Share	1.91	-0.65	2.55	-0.73	2.58	-0.73
	σ_x/σ_{y_n}	$\rho(x,y_n)$	σ_x/σ_{y_n}	$\rho(x,y_n)$	σ_x/σ_{y_n}	$\rho(x,y_n)$
Ag. Output	1.27	-0.31	1.79	-0.49	1.92	-0.47
Non-Ag. Employment	0.90	0.96	0.92	0.97	0.92	0.97
Ag. Employment	1.29	-0.43	1.84	-0.54	1.97	-0,52

Table 6: Benchmark Economy with $corr(\varepsilon_a, \varepsilon_n) = 1/2$ and $\sigma_{\varepsilon_a} = \sigma_{\varepsilon_n}$

e	.1	.2	.3	.4	.5	.6	.7	.8	.9
					σ_x/σ_y				
Employment	0.56	0.56	0.55	0.55	0.54	0.55	0.57	0.66	1.18
Non-Ag. Emp.	0.97	0.97	0.98	0.98	0.98	0.99	1.00	1.03	1.13
Ag. Employment	0.04	0.09	0.16	0.25	0.37	0.56	0.86	1.48	3.43
Ag. Output Share	0.89	0.91	0.93	0.98	1.04	1.17	1.39	1.91	3.75
					σ_x/σ_{y_n}				
Ag. Output	0.15	0.15	0.18	0.24	0.33	0.49	0.75	1.27	2.77
Non-Ag. Emp.	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.90	0.92
Ag. Employment	0.04	0.09	0.15	0.23	0.33	0.51	0.77	1.29	2.79
					$\rho(x, y)$				
Employment	0.94	0.94	0.93	0.92	0.89	0.83	0.73	0.49	0.11
Non-Ag. Emp.	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.92
Ag. Employment	−0.34	−0.35	−0.35	−0.31	−0.35	−0.32	−0.33	−0.31	−0.30
Ag. Output Share	−0.95	−0.95	−0.95	−0.93	−0.91	−0.86	−0.78	−0.65	−0.48
					$\rho(x, y_n)$				
Ag. Output	0.61	0.56	0.47	0.33	0.13	−0.01	−0.17	−0.31	−0.50
Non-Ag. Emp.	0.95	0.96	0.95	0.96	0.96	0.96	0.96	0.96	0.97
Ag. Employment	−0.34	−0.35	−0.36	−0.33	−0.38	−0.36	−0.40	−0.43	−0.54

Table 7: Benchmark Economy with $e = 0.8$ and $\sigma_{\varepsilon_a} = \sigma_{\varepsilon_n}$

$corr(\varepsilon_n, \varepsilon_a)$	0	1/6	1/3	1/2	2/3	5/6	1
				σ_x/σ_y			
Employment	0.62	0.63	0.65	0.66	0.67	0.69	0.70
Non-Ag. Employment	1.13	1.09	1.06	1.03	1.00	0.96	0.93
Ag. Employment	2.11	1.91	1.71	1.49	1.22	0.91	0.39
Ag. Output Share	2.72	2.47	2.21	1.92	1.59	1.16	0.51
				σ_x/σ_{y_n}			
Ag. Output	1.65	1.54	1.42	1.28	1.09	0.86	0.47
Non-Ag. Employment	0.91	0.90	0.90	0.90	0.89	0.89	0.88
Ag. Employment	1.71	1.58	1.46	1.30	1.09	0.84	0.37
				$\rho(x, y)$			
Employment	0.07	0.22	0.35	0.49	0.62	0.77	0.91
Non-Ag. Employment	0.95	0.95	0.95	0.95	0.95	0.95	0.96
Ag. Employment	−0.58	−0.51	−0.42	−0.32	−0.20	0.03	0.67
Ag. Output Share	−0.76	−0.73	−0.69	−0.65	−0.64	−0.63	−0.99
				$\rho(x, y_n)$			
Ag. Output	−0.64	−0.55	−0.45	−0.31	−0.16	0.16	0.99
Non-Ag. Employment	0.97	0.97	0.96	0.96	0.96	0.96	0.96
Ag. Employment	−0.69	−0.63	−0.54	−0.43	−0.31	−0.05	0.67

Table 8: Benchmark Economy with Changes in $\frac{\sigma_{\varepsilon_a}}{\sigma_{\varepsilon_n}}$

$\frac{\sigma_{\varepsilon_a}}{\sigma_{\varepsilon_n}}$	1	2	5	10	20
			σ_x/σ_y		
Employment	0.67	0.88	1.33	1.92	2.67
Non-Ag. Employment	1.03	1.09	1.15	1.20	1.29
Ag. Employment	1.50	2.49	3.93	5.81	9.24
Ag. Output Share	1.93	2.88	4.22	5.92	8.95
			σ_x/σ_{y_n}		
Ag. Output	1.28	2.05	3.11	4.44	6.51
Non-Ag. Employment	0.90	0.91	0.92	0.93	0.95
Ag. Employment	1.31	2.08	3.13	4.49	6.77
			$\rho(x, y)$		
Employment	0.49	0.23	0.13	0.12	0.17
Non-Ag. Employment	0.95	0.93	0.89	0.82	0.69
Ag. Employment	−0.30	−0.32	−0.23	−0.14	−0.02
Ag. Output Share	−0.64	−0.55	−0.40	−0.27	−0.11
			$\rho(x, y_n)$		
Ag. Output	−0.31	−0.43	−0.48	−0.51	−0.56
Non-Ag. Employment	0.96	0.97	0.97	0.97	0.97
Ag. Employment	−0.42	−0.50	−0.52	−0.54	−0.59