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AGENCY COSTS AND INVESTMENT BEHAVIOUR

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Founded in 1963 by two prominent Austrians living in exile – the sociologist Paul F. Lazarsfeld and the economist Oskar Morgenstern – with the financial support from the Ford Foundation, the Austrian Federal Ministry of Education and the City of Vienna, the Institute for Advanced Studies (IHS) is the first institution for postgraduate education and research in economics and the social sciences in Austria. The **Economics Series** presents research done at the Department of Economics and Finance and aims to share “work in progress” in a timely way before formal publication. As usual, authors bear full responsibility for the content of their contributions.

Das Institut für Höhere Studien (IHS) wurde im Jahr 1963 von zwei prominenten Exilösterreichern – dem Soziologen Paul F. Lazarsfeld und dem Ökonomen Oskar Morgenstern – mit Hilfe der Ford-Stiftung, des Österreichischen Bundesministeriums für Unterricht und der Stadt Wien gegründet und ist somit die erste nachuniversitäre Lehr- und Forschungsstätte für die Sozial- und Wirtschaftswissenschaften in Österreich. Die **Reihe Ökonomie** bietet Einblick in die Forschungsarbeit der Abteilung für Ökonomie und Finanzwirtschaft und verfolgt das Ziel, abteilungsinterne Diskussionsbeiträge einer breiteren fachinternen Öffentlichkeit zugänglich zu machen. Die inhaltliche Verantwortung für die veröffentlichten Beiträge liegt bei den Autoren und Autorinnen.

Abstract

How do differences in the creit channel affect investment behavior in the U.S. and the Euro area? To analyze this question, we calibrate an agency cost model of business cycles. We focus on two key components of the lending channel, the default premium associated with bank loans and bankruptcy rates, to identify the differences in the U.S. and European financial sectors. Our results indicate that the differences in financial structures affect quantitatively the cyclical behavior in the two areas: the magnitude of the credit channel effects is amplified by the differences in the financial structures. We further demonstrate that the effects of minor differences in the credit market translate into large, persistent and asymmetric fluctuations in price of capital, bankruptcy rate and risk premium. The effects imply that the Euro Area's supply elasticities for capital are less elastic than the U.S.

Keywords

Agency costs, credit channel, investment behavior, E.U. Area

JEL Classification

E4, E5, E2

Comments

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1 Introduction

The standard real business cycle (RBC) model of Kydland and Prescott (1982) claims that exogenous aggregate technology shocks drive economic fluctuation.[1] But these shocks need to be large and persistent in order to match various stylized facts.[2] Indeed, Cochrane (1994) shows that there are other possible candidates of shocks, and illustrates the difficulty in identifying and attributing a particular shock that could explain the observed business cycles.

In recent years a number of theoretical models that highlights the role of financial accelerator in propagating and amplifying macroeconomic shocks has further casted doubts on aggregate techonology shocks in the standard RBC model as the driving force in business activities.[3] This literature addresses the question "can credit constraints and (or) asymmetric information between borrows and lenders propagate and amplify business cycles?" Although the theoretical contributions have improved our understanding of the propagation mechnism, the lack of empirical support has led many to question the relevance of financial accelerator type models.[4]

In this paper, we continue with this empirical debate by posing a question "How do differences in the credit channel affect investment behavior in the U.S. and the Euro area?" To

[1] King and Rebelo (2000) surveys a recent development in real business cycle literature and presents further support of this claim.

[2] For example, Cogley and Nason (1995) show that standard RBC models cannot deliever a hump-shaped response of output to a transient shock that is consistent with U.S. time series.

[3] Financial accelerator models are usually clasified into two catergories: agency costs models and credit constraint models. Some prominent contributions in agency costs literature are: Williamson (1987), Bernanke and Gertler (1989, 1990), Bernanke, Gertler, and Gilchrist (1999), and Carlstrom and Fuerst (1997). For constraint models, see Scheinkman and Weiss (1986), Kiyotaki and Moore (1997), Kiyotaki (1998), Cooley and Quadrini (2001), and Kocherlakota (2000). Walsh (2003) presents an overview, both theoretical and empirical, of the literature.

[4] See, for example, Fisher (1999), Kocherlakota (2000), Cole and Ohanian (2000), Cooper and Ejarque (2000), Arias (2002), and Cordoba and Ripoll (2003) for a negative stance on the role that financial sector plays in the actual economy. Carlstrom and Fuerst (1997) and Dorofeenko, Lee and Salyer (2003) are the only few that document the empirical relevance for financial acceleration.

Table 1: Financial Sector Information on Euro Area Countries and U.S

Country	**Bankruptcy Rate**	**Risk Premium**
Austria (German Civil Law)	0.332	3.76
Ireland (English Common Law)	0.685	8.85
Spain (Frech Civil Law)	0.0005	1.99
U.S. (English Common Law)	0.974	1.87

Source: See Data Appendix. The bankruptcy rates for the E.U. countries are calculated as an average percentage of bankruptcies to number of firms for the period between 1990 - 1999. Risk Premia are the differences between lending and deposit rates. For the U.S. numbers, see Carlstrom and Fuerst (1997).

analyze this question, we calibrate a version of the Carlstrom and Fuerst (1997) agency cost model of business cycles for these two economies. Agresti and Mojon (2001) and Cecchetti (1999) show that these two monetary unions exhibit similar business cycle patterns but quite different in financial structures. For expositional purpose, Figure 1 shows the autocorrelation functions (ACF) for output growth for the U.S. and some of the Euro Area countries (including the aggregate EMU11). These ACFs clearly show that the business cycle patters between the two monetary unions are similar.

We focus on two key components of the lending channel, the default premium associated with bank loans and bankruptcy rates, in order to identify the differences in the U.S. and European financial sectors. More specifically, for the Euro Area countries, we focus on Austria, Ireland and Spain. These three countries represent three different legal system and are known to have either low bankruptcy rate (e.g. Spain) or high risk premium (e.g. Ireland): see Table 1.[5]

Our results indicate that the differences in financial structures quantitatively affect the

[5] We also include Austria as a case where both the bankruptcy rate and risk premium lie between the two extremes of Ireland and Spain.

cyclial behavior in the two areas: the magnitude of the credit channel effects is amplified by the differences in the financial structures. We further demonstrate that the effects of minor differences in the credit market translate into large, persistent and asymmetric fluctuations in price of capital, bankruptcy rate and risk premium. The effects imply that the Euro Area's supply elasticities for capital are less elastic than the U.S. We conclude that the financial accelerator mechanism could potentially play a significant role in business cycles in the Euro area.

The next section presents the model while the following section discusses equilibrium characteristics. The final section offers some concluding comments. The derivation for the steady state analysis is given in the appedix. And the data appendix is listed separately at the end.

2 Model

We employ the agency cost business cycle model of Carlstrom and Fuerst (1997) to address the financial intermediaries' role in the propagation of productivity shocks across different monetary unions. Since, for the most part, the model is identical to that in Carlstrom and Fuerst, the exposition of the model will be brief.

The model is a variant of a standard RBC model in which an additional production sector is added. This sector produces capital using a technology which transforms investment into capital. In a standard RBC framework, this conversion is always one-to-one; in the Carlstrom and Fuerst framework, the production technology is subject to technology shocks. (The aggregate production technology is also subject to technology shocks as is standard.) This capital production sector is owned by entrepreneurs who finance their production via loans from a risk neutral financial intermediation sector - this lending channel is characterized by a loan contract with a fixed interest rate. (Both capital production and the loans are intra-period.) If a capital producing firm realizes a low technology shock, it will declare bankruptcy and the financial intermediary will take over production; this activity is subject to monitoring costs. With this brief description, we now turn to an explicit characterization of the economy.

2.1 Households

The representative household is infinitely lived and has expected utility over consumption c_t and leisure $1 - l_t$ with functional form given by:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\ln(c_t) + \nu (1 - l_t) \right] \tag{1}$$

where E_0 denotes the conditional expectation operator on time zero information, $\beta \in (0, 1)$, $\nu > 0$, and l_t is time t labor. The household supplies labor, l_t, and rents its accumulated capital stock, k_t, to firms at the market clearing real wage, w_t, and rental rate r_t, respectively, thus earning a total income of $w_t l_t + r_t k_t$. The household then purchases consumption good from firms at price of one (i.e. consumption is the numeraire), and purchases new capital, i_t, at a price of q_t. Consequently, the household's budget constraint is

$$w_t l_t + r_t k_t \geq c_t + q_t i_t \tag{2}$$

The law of motion for households' capital stock is standard:

$$k_{t+1} = (1-\delta)\, k_t + i_t \tag{3}$$

where $\delta \in (0,1)$ is the depreciation rate on capital.

The necessary conditions associated with the maximization problem include the standard labor-leisure condition and the intertemporal efficiency condition associated with investment. Given the functional form for preferences, these are:

$$\nu c_t = w_t \tag{4}$$

$$\frac{q_t}{c_t} = \beta E_t \left[\frac{q_{t+1}(1-\delta) + r_{t+1}}{c_{t+1}} \right] \tag{5}$$

2.2 Firms

The economy's output of the consumption good is produced by firms using Cobb-Douglas technology[6]

$$Y_t = \theta_t K_t^{\alpha_K} H_t^{\alpha_H} \left(H_t^e\right)^{\alpha_{H^e}} \tag{6}$$

where Y_t represents the aggregate output, θ_t denotes the aggregate technology shock, K_t denotes the aggregate capital stock, H_t denotes the aggregate household labor supply, H_t^e denotes the aggregate supply of entrepreneurial labor, and $\alpha_K + \alpha_H + \alpha_{H^e} = 1$.[7]

[6] Note that we denote aggregate variables with upper case while lower case represents per-capita values. Prices are also lower case.

[7] As in Carlstrom and Fuerst, we assume that the entrepreneur's labor share is small, in particular, $\alpha_{H^e} = 0.0001$. The inclusion of entrepreneurs' labor into the aggregate production function serves as a

The profit maximizing representative firm's first order conditions are given by the factor market's condition that wage and rental rates are equal to their respective marginal productivities:

$$w_t = \theta_t \alpha_H \frac{Y_t}{H_t} \tag{7}$$

$$r_t = \theta_t \alpha_K \frac{Y_t}{K_t} \tag{8}$$

$$w_t^e = \theta_t \alpha_{H^e} \frac{Y_t}{H_t^e} \tag{9}$$

where w_t^e denotes the wage rate for entrepreneurial labor.

2.3 Entrepreneurs

A risk neutral representative entrepreneur's course of action is as follows. To finance his project at period t, he borrows resources from the Capital Mutual Fund according to an optimal financial contract. The entire borrowed resources, along with his total net worth at period t, are then invested into his capital creation project. If the representative entrepreneur is solvent after observing his own technology shock, he then makes his consumption decision; otherwise, he declares bankruptcy and production is monitored (at a cost) by the Capital Mutual Fund.

2.4 Optimal Financial Contract

The optimal financial contract between entrepreneur and the Capital Mutual Fund is described by Carlstrom and Fuerst (1997). But for expository purposes as well as to explain

technical device so that entrepreneurs' net worth is always positive, even when insolvent.

our approach in addressing the second moment effect on equilibrium conditions, we briefly outline the model.

The entrepreneur has access to a stochastic technology that transforms i_t units of consumption into $\omega_t i_t$ units of capital. The investment technology shock ω_t is distributed as *i.i.d.* with the lognormal distribution Φ that has a mean of unity and a standard deviation of σ. The realization of ω_t is privately observed by entrepreneur – banks can observe the realization at a cost of μi_t units of consumption.

The entrepreneur enters period t with one unit of labor endowment and z_t units of capital. Labor is supplied inelastically while capital is rented to firms, hence income in the period is $w_t + r_t z_t$. This income along with remaining capital determines net worth (denominated in units of consumption) at time t:

$$n_t = w_t + z_t \left(r_t + q_t \left(1 - \delta\right)\right) \tag{10}$$

With a positive net worth, the entrepreneur borrows $(i_t - n_t)$ consumption goods and agrees to pay back $\left(1 + r^k\right)(i_t - n_t)$ capital goods to the lender, where r^k is the interest rate on loans. Thus, the entrepreneur defaults on the loan if his realization of output is less then the re-payment, i.e.

$$\omega_t < \frac{\left(1 + r^k\right)(i_t - n_t)}{i_t} \equiv \bar{\omega}_t \tag{11}$$

The optimal borrowing contract is given by the pair $(i, \bar{\omega})$ that maximizes entrepreneur's return subject to the lender's willingness to participate (all rents go to the entrepreneur). Denoting the *c.d.f.* and *p.d.f.* of ω_t as $\Phi(\omega_t)$ and $\phi(\omega_t)$ respectively, the contract is determined by the solution to:[8]:

$$\max_{\{i,\bar{\omega}\}} qif(\bar{\omega}) \text{ subject to } qig(\bar{\omega}) \geq (i-n)$$

where

$$f(\bar{\omega}) = \left[\int_{\bar{\omega}}^{\infty} \omega\phi(\omega)\,d\omega - [1-\Phi(\bar{\omega})]\,\bar{\omega}\right]$$

which can be interpreted as the fraction of the expected net capital output received by the entrepreneur[9],

$$g(\bar{\omega}) = \left[\int_{0}^{\bar{\omega}} \omega\phi(\omega)\,d\omega + [1-\Phi(\bar{\omega})]\,\bar{\omega} - \Phi(\bar{\omega})\,\mu\right]$$

which represents the lender's fraction of expected capital output, $\Phi(\bar{\omega})$ is the bankruptcy rate so that $\Phi(\bar{\omega})\,\mu$ denotes monitoring costs. Also note that $f(\bar{\omega})+g(\bar{\omega}) = 1-\Phi(\bar{\omega})\,\mu$: the RHS is the average amount of capital that is produced – this is split between entrepreneurs and lenders. Hence the presence of monitoring costs reduces net capital production.[10]

[8] This notation is imprecise in that it implies the distributions are time-invariant. That is, the *c.d.f.* should be expressed as $\Phi_t(\omega_t) \equiv \Phi(\omega_t; \omega_{t-1}, \mu_t)$ with the *p.d.f.* expressed as $\phi_t(\omega_t) \equiv \phi(\omega_t; \omega_{t-1}, \mu_t)$. For simplicity, we suppress the time-notation.

[9] The deriviative of this function is $f'(\bar{\omega}) = \Phi(\bar{\omega}) - 1$. Thus, as $\Phi(\bar{\omega}) \in [0,1]$, we have $f'(\bar{\omega}) \leq 0$. That is, as the lower bound for the realization of the technology shock (or the cutoff bankruptcy rate) increases, the entrepreneur's output share goes down.

[10] This suggests that monitoring costs are akin to investment adjustment costs - in fact, Carlstrom and Fuerst demonstrate that this is the case. The important difference between this model and a model with adjustment costs is that entrepreneurs' net worth is an endogenous state variable that affects the dynamics of the economy - this feature is not present in an adjustment cost model.

The necessary conditions for the optimal contract problem are

$$\begin{aligned}
\frac{\partial(.)}{\partial\bar{\omega}} &: \quad qif'(\bar{\omega}) = -\lambda ig'(\bar{\omega}) \\
&\Rightarrow \quad \lambda = \frac{-f'(\bar{\omega})}{g'(\bar{\omega})} \\
\lambda &= \quad \frac{f'(\bar{\omega})}{\phi(\bar{\omega})\mu + f'(\bar{\omega})} \\
\lambda &= \quad \frac{1-\Phi(\bar{\omega})}{1-\Phi(\bar{\omega}) - \phi(\bar{\omega})\mu}
\end{aligned}$$

where λ is the shadow price of capital. This can be rewritten as:

$$1 - \frac{1}{\lambda} = \frac{\phi(\bar{\omega})}{1-\Phi(\bar{\omega})}\mu \tag{12}$$

As shown by eq.(12), the shadow price of capital is an increasing function of the relevant Inverse Mill's ratio (interpreted as the conditional probability of bankruptcy) and the agency costs. If the product of these terms equals zero, then the shadow price equals the cost of capital production, i.e. $\lambda = 1$.

The second necessary condition is:

$$\frac{\partial(.)}{\partial i} : qf(\bar{\omega}) = -\lambda\left[1 - qg(\bar{\omega})\right]$$

Solving for q using the first order conditions, we have

$$\begin{aligned} q &= \left[\left(f(\bar{\omega}) + g(\bar{\omega}) \right) + \frac{\phi(\bar{\omega})\,\mu f(\bar{\omega})}{f'(\bar{\omega})} \right]^{-1} \\ &= \left[1 - \Phi(\bar{\omega})\,\mu + \frac{\phi(\bar{\omega})\,\mu f(\bar{\omega})}{f'(\bar{\omega})} \right]^{-1} \\ &\equiv \left[1 - D(\bar{\omega}) \right]^{-1} \end{aligned} \tag{13}$$

where $D(\bar{\omega})$ can be thought of as the total default costs.

Equation (13) defines an implicit function $\bar{\omega}(q)$ that is increasing in q, or the price of capital that incorporates the expected bankruptcy costs. The price of capital, q, differs from unity due to the presence of the credit market friction. That is, to compensate for the bankruptcy (monitoring) costs, there must be a premium on the price of capital. And this premium is set by the amount of monitoring costs and the probability of bankruptcy. (Note that $f'(\bar{\omega}) = \Phi(\bar{\omega}) - 1 < 0$.)

Finally, the incentive compatibility constraint implies

$$i = \frac{1}{(1 - qg(\bar{\omega}))} n \tag{14}$$

Equation (14) implies that investment is linear in net worth and defines a function that represents the amount of consumption goods placed in to the capital technology: $i(q, n)$. The fact that the function is linear implies that the aggregate investment function is well defined.

2.5 Entrepreneur's Consumption Choice

To rule out self-financing by the entrepreneur (i.e. which would eliminate the presence of agency costs), it is assumed that the entrepreneur discounts the future at a faster rate than the household. This is represented by following expected utility function:

$$E_0 \sum_{t=0}^{\infty} (\beta\gamma)^t c_t^e \tag{15}$$

where c_t^e denotes entrepreneur's consumption at date t, and $\gamma \in (0,1)$. This new parameter, γ, will be chosen so that it offsets the steady-state internal rate of return to entrepreneurs' investment.

At the end of the period, the entrepreneur finances consumption out of the returns from the investment project implying that the law of motion for the entrepreneur's capital stock is:

$$z_{t+1} = n_t \left\{ \frac{f(\bar{\omega}_t)}{1 - q_t g(\bar{\omega}_t)} \right\} - \frac{c_t^e}{q_t} \tag{16}$$

Note that the expected return to internal fund is $\frac{q_t f(\bar{\omega}_t) i_t}{n_t}$; that is, the net worth of size n_t is leveraged into a project of size i_t, entrepreneurs keep the share of the capital produced and capital is priced at q_t consumption goods. Since these are intra-period loans, the opportunity cost is 1.[11]

Consequently, the representative entrepreneur maximizes his expected utility function in equation (15) over consumption and capital subject to the law of motion for capital, equation (16), and the definition of net worth given in equation (10). The resulting Euler equation is

[11] As noted above, we require in steady-state $1 = \gamma \frac{q_t f(\bar{\omega}_t)}{(1 - q_t g(\bar{\omega}_t))}$.

as follows:

$$q_t = \beta\gamma E_t \left\{ \left[q_{t+1}(1-\delta) + r_{t+1}\right] \left[\frac{q_{t+1} f(\bar{\omega}_{t+1})}{(1 - q_{t+1} g(\bar{\omega}_{t+1}))} \right] \right\}$$

2.6 Financial Intermediaries

The Capital Mutual Funds (CMFs) act as risk-neutral financial intermediaries who earn no profit and produce neither consumption nor capital goods. There is a clear role for the CMF in this economy since, through pooling, all aggregate uncertainty of capital production can be eliminated. The CMF receives capital from three sources: entrepreneurs sell undepreciated capital in advance of the loan, after the loan, the CMF receives the newly created capital through loan repayment and through monitoring of insolvent firms, and, finally, those entrepreneur's that are still solvent, sell some of their capital to the CMF to finance current period consumption. This capital is then sold at the price of q_t units of consumption to households for their investment plans.

2.7 Equilibrium

There are four markets: labor markets for households and entrepreneurs, goods markets for consumption and capital.

$$H_t = (1-\eta)\, l_t \tag{17}$$

where η denotes the fraction of entrepreneurs in the economy.

$$H_t^e = \eta \tag{18}$$

$$C_t + I_t = Y_t \tag{19}$$

where $C_t = (1-\eta)\, c_t + \eta c_t^e$ and $I_t = \eta i_t$.

$$K_{t+1} = (1-\delta)\, K_t + I_t \left[1 - \Phi(\bar{\omega})\, \mu\right] \tag{20}$$

A competitive equilibrium is defined by the decision rules for $\{K_{t+1}, Z_{t+1}, H_t, H_t^e, q_t, n_t, i_t, \bar{\omega}_t, c_t, c_t^e\}$ where these decision rules are stationary functions of $\{K_t, Z_t, \theta_t\}$ and satisfy the following equations[12]

$$\begin{aligned}
\nu c_t &= \theta_t \alpha_H \frac{Y_t}{H_t} && (21)\\
\frac{q_t}{c_t} &= \beta E_t \left[\frac{1}{c_{t+1}} \left(q_{t+1}(1-\delta) + \theta_{t+1}\alpha_K \frac{Y_{t+1}}{K_{t+1}}\right)\right] && (22)\\
q_t &= \left[1 - \Phi(\bar{\omega}_t)\, \mu + \frac{\phi(\bar{\omega})\, \mu f(\bar{\omega}_t)}{f'(\bar{\omega}_t)}\right]^{-1} && (23)\\
i_t &= \frac{1}{(1 - q_t g(\bar{\omega}_t))} n_t && (24)\\
q_t &= \beta\gamma E_t \left\{\left[q_{t+1}(1-\delta) + \theta_{t+1}\alpha_K \frac{Y_{t+1}}{K_{t+1}}_{t+1}\right] \left[\frac{q_{t+1} f(\bar{\omega}_{t+1})}{(1 - q_{t+1} g(\bar{\omega}_{t+1}))}\right]\right\} && (25)\\
n_t &= \theta_t \alpha_{H^e} \frac{Y_t}{H_t^e} + z_t \left[q_t (1-\delta) + \theta_t \alpha_K \frac{Y_t}{K_t}\right] && (26)\\
Z_{t+1} &= \eta n_t \left\{\frac{f(\bar{\omega}_t)}{1 - q_t g(\bar{\omega}_t)}\right\} - \eta \frac{c_t^e}{q_t} && (27)\\
\theta_{t+1} &= \theta_t^\rho \xi_{t+1} \text{ where } \xi_t \sim i.i.d. \text{ with } E(\xi_t) = 1 && (28)
\end{aligned}$$

[12] A more thorough presentation of the equilibrium conditions are presented in the Appendix.

3 Equilibrium Characteristics

3.1 Steady-state analysis

While our focus is primarily on the cyclical behavior of the economy, we briefly examine the steady-state properties of the economies. For this analysis, we use, to a large extent, the parameters employed in Carlstrom and Fuerst's (1997) analysis for the U.S. and Casares (2001) for the Euro Area countries.. Specifically, the following parameter values are used:

Table 2: Parameter Values

	β	α	δ	μ	ρ
U.S.	0.99	0.36	0.02	0.25	0.95
Euro Area	0.995	0.36	0.025	0.25	0.95

Agents discount factor, the depreciation rate and capital's share are fairly standard in RBC analysis. The remaining parameter, μ, represents the monitoring costs associated with bankruptcy. This value, as noted by Carlstrom and Fuerst (1997) is relatively prudent given estimates of bankruptcy costs (which range from 20% (Altman (1984) to 36% (Alderson and Betker (1995) of firm assets).

The remaining parameters, (σ, γ), determine the steady-state bankruptcy rate (which we denote as br and is expressed in percentage terms) and the risk premium (denoted rp) associated with bank loans.[13] (Also, recall that γ is calibrated so that the rate of return to internal funds is equal to $\frac{1}{\gamma}$.)[14] While Carlstrom and Fuerst found it useful to use the

[13] The equations defining the steady-state are presented in the Appendix. This derivation also demonstrates that the parameter η (the fraction of entrepreneurs in the economy) is strictly a normalization and does not influence equilibrium characteristics.

[14] The fraction of entrepreneurs in the economy, η, is not a critical parameter for the behavior of the economy. As Carlstrom and Fuerst note, it is simply a normalization. Aggregate consumption in the model

observed bankruptcy rate to determine σ, for our analysis we treat σ and br as exogenous and examine the steady state behavior of the economy under different scenarios. In particular we consider the following four economies as displayed in Table 3, where the values of γ are reported strictly for comparison. That is, once the values of σ and br are specified, the value of γ is determined endogenously. For these experiments, we varied σ and γ so that they reamined consistent wtih a risk premium for each economy. The main message from Table 3 is that the combination of increase in the bankruptcy rate and the risk premium contributes in increasing uncertainty (σ) and hence an increase in the cut-off points for the changes in the distribution of the lending channel ($\bar{\omega}$) . For example, the combination of low bankruptcy rate but relatively high risk premium for Spain leads to high degrees of uncertainty, which then leads to the highest lending cut-off point.

Table 3: Four Economies

Economy	$\bar{\omega}$	$\boldsymbol{\sigma}$	br (%)	$\boldsymbol{\gamma}$
U.S. ($C\&F$)	-0.06	0.207	0.974	0.9474
Austria	-2.35	0.761	0.33	0.9653
Ireland	-2.46	0.852	0.685	0.9336
Spain	-5.98	1.315	0.005	0.9844

3.2 Cyclical Behavior

As described in Section 2, eqs. (21) through (28) determine the equilibrium properties of the economy. To analyze the cyclical properties of the economy, we linearize (i.e. take a first-

is indeed a weighted average of household and entrepreneurial consumption but the weights are determined by the steady-state level of per-capita consumption for these groups. This is endogenously determined - but not by η. This is demonstrated at the end of the Appendix.

order Taylor series expansion) of these equations around the steady-state values and express all terms as percentage deviations from steady-state values. This numerical approximation method is standard in quantitative macroeconomics.

The behavior of these four economies is analyzed by examining the impulse response functions of several key variables to a 1% innovation in θ with the pesistency of shock to be 0.95. These are presented in Figures 2-4. As in Carlstrom and Fuerst, the standard deviation of the technology shock ω_t is, on average, equal to 0.207. That is, we set $\bar{\sigma}_\omega = 0.207$.

We first turn to aggregate output and household consumption and investment. With greater positive productivity shock, as expected, aggregate output, consumption and investment all increase. And the magnitude of increase across different economies is almost equivalent. These effects are shown in Figures 2 - 4. As in Carlstrom and Fuerst, a technology shock increases output and the demand for capital. The resulting increase in the price of capital implies greater lending activity and, hence, an increase in the bankruptcy rate (and risk premia) as shown in Figures 5 - 7. Our focus, as was in Carlstrom and Fuerst, was on the effects of innovation to the aggregate technology shock and, because of the assumed persistence in this shock, is driven by the change in the first moment of the aggregate production shock. What is different in our results in compare to Carlstrom and Fuerst is the magnitude of the impulse response functions for bankruptcy rate, risk premium and price of capital across different economies. As the cut-off point increases (ω), the response of capital price is increases (see Figure 7). This is a direct evidence that the Euro Area's supply elasticities for capital are less elastic than the U.S.

4 Conclusion

Theoretical works on the credit channel effect on aggregate economic varialbes in the last ten years has seen a proliferation of macroeconomic models. The common element in this literature is that lending activity is characterized by asymmetric information between borrowers and lenders. As a consequence, interest rates may not move to clear lending markets (as in models with moral hazard and adverse selection elements) or firms' net worth may play a critical role as collateral in influencing lending activity (as in models with agency costs). While debate on the empirical support for these models continues, there is little doubt that, as a whole, they have improved our understanding of financial intermediation and broadened the scope of how monetary policy, through the impact of interest rates on firms' net worth, can influence macroeconomic performance.

Our attempt in this paper is to show empirically that the credit channel effect matters and that the effect propagates and amplifies business cycles. Our result is in direct contrast to the recent findings by Angeloni, Kashyap, Mojon and Terlizzese (2003) who state that the interest rate channel alone could explain most of the monetary policies in the Euro Area. Our and Angeloni and et al's results differ due mainly due to the nature of methodology: we calibrate a dynamic stochastic general equilibrium whereas Agenloni and et al estimate reduced form equations.

Our primary findings fall into two broad categories. First, aggregate technology shock could propagate and amplify various aggregate macroeconomic variables in an environment where there is a financial intermediation. i.e. where there is a credit channel effect. Second, when compare to various economies that differ only in two financial dimention (bankruptcy rate and risk premium), we find that the magnitude of shocks to aggregate technology may be quantitatively large. We demonstrate that the effects of minor differences in the credit market translate into large, persistent and asymmetric fluctuations in price of capital, bankruptcy rate and risk premium. The effects imply that the Euro Area's supply elasticities for capital are less elastic than the U.S. We conclude that the financial accelerator mechanism could potentially play a significant role in business cycles in the Euro area. This result directly lends one to conclude the following: the credit channel that affects the financial sector do indeed matter for macroeconomic behavior.

With the central role that information plays in these models, they present a potentially rich environment to study the effects that changes in uncertainty have on aggregate economic behavior. For future research, together with the results in this paper , an analysis of the effects that uncertainty has on aggregate economic performance across different economies would be fruitful. To do this, one could introduce time-varying uncertainty as in Dorofeenko, Lee and Salyer (2003), i.e. second moment effects, into the agency cost model of Carlstrom and Fuerst (1997). Within this setting, we could model time varying uncertainty as a mean preserving spread in the distribution of the technology shocks affecting capital production and explore how changes in uncertainty affect equilibrium characteristics.

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5 Appendix:

5.1 Steady-state conditions in the Carlstrom and Fuerst Agency Cost Model

We first present the equilibrium conditions and express these in scaled (by the fraction of entrepreneurs in the economy) terms. Then the equations are analyzed for steady-state implications. As in the text, upper case variables denote aggregate wide while lower case represent household variables. Preferences and technology are:

$$\begin{aligned} U(\tilde{c}, 1-l) &= \ln \tilde{c} + \nu (1-l) \\ Y &= \theta K^{\alpha} \left[(1-\eta) l\right]^{1-\alpha-\phi} \eta^{\phi} \end{aligned}$$

Where ηdenotes the fraction of entrepreneurs in the economy and θ is the aggregate technology shock. Note that aggregate household labor is $L = (1-\eta) l$while entrepreneurs inelastically supply one unit of labor. We assume that the share of entrepreneur's labor is approximately zero so that the production function is simply

$$Y = \theta K^{\alpha} \left[(1-\eta) l\right]^{1-\alpha}$$

This assumption implies that entrepreneurs receive no wage income (see eq. (9) in C&F. There are nine equilibrium conditions:

The resource constraint

$$(1-\eta)\tilde{c}_t + \eta c_t^e + \eta i_t = Y_t = \theta_t K_t^\alpha \left[(1-\eta) l_t\right]^{1-\alpha} \tag{29}$$

Let $c = \frac{(1-\eta)\tilde{c}}{\eta}$, $h = \frac{(1-\eta)}{\eta} l$, and $k_t = \frac{K_t}{\eta}$ then eq(29) can be written as:

$$c_t + c_t^e + i_t = \theta_t k_t^\alpha h_t^{1-\alpha} \tag{30}$$

Household's intratemporal efficiency condition

$$\tilde{c}_t = \frac{(1-\alpha)}{\nu} K_t^\alpha \left[(1-\eta) l_t\right]^{-\alpha}$$

Defining $\nu_0 = \frac{\eta}{1-\eta}\nu$, this can be expressed as:

$$\nu_0 c_t = (1-\alpha) k_t^\alpha h_t^{-\alpha} \tag{31}$$

Law of motion of aggregate capital stock

$$K_{t+1} = (1-\delta) K_t + \eta i_t \left[1 - \Phi(\bar{\omega}_t) \mu\right]$$

Dividing by ηyields the scaled version:

$$k_{t+1} = (1-\delta) k_t + i_t \left[1 - \Phi(\bar{\omega}_t) \mu\right] \tag{32}$$

Household's intertemporal efficiency condition

$$q_t \frac{1}{\tilde{c}_t} = \beta E_t \left\{ \frac{1}{\tilde{c}_{t+1}} \left[q_{t+1} (1-\delta) + \theta_{t+1} \alpha K_{t+1}^{\alpha-1} \left[(1-\eta) l_{t+1} \right]^{1-\alpha} \right] \right\}$$

Dividing both sides by $\frac{1-\eta}{\eta}$ and scaling the inputs by ηyields:

$$q_t \frac{1}{c_t} = \beta E_t \left\{ \frac{1}{c_{t+1}} \left[q_{t+1} (1-\delta) + \theta_{t+1} \alpha k_{t+1}^{\alpha-1} h_{t+1}^{1-\alpha} \right] \right\} \tag{33}$$

The conditions from the financial contract are already in scaled form:

Contract efficiency condition

$$q_t = \frac{1}{1 - \Phi(\bar{\omega}_t) \mu + \phi(\bar{\omega}_t) \mu \frac{f(\bar{\omega}_t)}{f'(\bar{\omega}_t)}} \tag{34}$$

Contract incentive compatibility constraint

$$\frac{i_t}{n_t} = \frac{1}{1 - q_t g(\bar{\omega}_t)} \tag{35}$$

Where n_t is entrepreneur's net worth.

Determination of net worth

$$\eta n_t = Z_t \left[q_t (1-\delta) + \theta_t K_t^{\alpha-1} \left[(1-\eta) l_t \right]^{1-\alpha} \right]$$

or, in scaled terms:

$$n_t = z_t \left[q_t (1-\delta) + \theta_t k_t^{\alpha-1} h_t^{1-\alpha} \right] \tag{36}$$

Note that z_t denotes (scaled) entrepreneur's capital.

Law of motion of entrepreneur's capital

$$Z_{t+1} = \eta n_t \left\{ \frac{f(\bar{\omega}_t)}{1 - q_t g(\bar{\omega}_t)} \right\} - \eta \frac{c_t^e}{q_t}$$

Or, dividing by η

$$z_{t+1} = n_t \left\{ \frac{f(\bar{\omega}_t)}{1 - q_t g(\bar{\omega}_t)} \right\} - \frac{c_t^e}{q_t} \tag{37}$$

Entrepreneur's intertemporal efficiency condition

$$q_t = \gamma\beta E_t \left\{ \left[q_{t+1} (1-\delta) + \theta_{t+1} \alpha K_{t+1}^{\alpha-1} \left[(1-\eta) l_{t+1} \right]^{1-\alpha} \right] \left(\frac{q_{t+1} f(\bar{\omega}_{t+1})}{1 - q_{t+1} g(\bar{\omega}_{t+1})} \right) \right\}$$

Or, in scaled terms:

$$q_t = \gamma\beta E_t \left\{ \left[q_{t+1} (1-\delta) + \theta_{t+1} \alpha k_{t+1}^{\alpha-1} h_{t+1}^{1-\alpha} \right] \left(\frac{q_{t+1} f(\bar{\omega}_{t+1})}{1 - q_{t+1} g(\bar{\omega}_{t+1})} \right) \right\} \tag{38}$$

5.2 Definition of Steady-state

Steady-state is defined by time-invariant quantities:

$$c_t = \hat{c}, c_t^e = \hat{c}^e, k_t = \hat{k}, \bar{\omega}_t = \hat{\omega}, h_t = \hat{h}, q_t = \hat{q}, z_t = \hat{z}, n_t = \hat{n}, i_t = \hat{\imath}$$

So there are nine unknowns. While we have nine equilibrium conditions, the two intertemporal efficiency conditions become identical in steady-state since C&F impose the condition that the internal rate of return to entrepreneur is offset by their additional discount factor:

$$\gamma \left(\frac{\hat{q} f(\hat{\omega})}{1 - \hat{q} g(\hat{\omega})} \right) = 1 \tag{39}$$

This results in an indeterminacy - but there is a block recursiveness of the model due to the calibration exercise. In particular, we demonstrate that the risk premium and bankruptcy rate determine $(\hat{\omega}, \sigma)$ - these in turn determine the steady-state price of capital. From eq.(33)we have:

$$\hat{q} = \frac{\alpha\beta}{1 - \beta(1-\delta)} \hat{k}^{\alpha-1} \hat{h}^{1-\alpha} = \frac{\alpha\beta}{1 - \beta(1-\delta)} \frac{\hat{y}}{\hat{k}} \tag{40}$$

From eq.(31)we have:

$$\hat{h} = \frac{1-\alpha}{\nu_0} \frac{\hat{k}^{\alpha} \hat{h}^{1-\alpha}}{\hat{c}} = \frac{1-\alpha}{\nu_0} \frac{\hat{y}}{\hat{c}} \tag{41}$$

From eq.(32)we have:

$$\hat{k} = \frac{1 - \Phi(\hat{\omega}) \mu}{\delta} \hat{\imath} \tag{42}$$

Note that these three equations are normally (i.e. in a typical RBC framework) used to find steady-state $\left(\hat{k}, \hat{h}, \hat{c}\right)$ - because $\hat{q}=1$. Here since the price of capital is endogenous, we have four unknowns. From eq. (36)and eq. (33)we have

$$\hat{n}=\hat{z}\left(\hat{q}\left(1-\delta\right)+\alpha\frac{\hat{y}}{\hat{k}}\right)=\hat{z}\frac{\hat{q}}{\beta} \tag{43}$$

From eq. (37)and the restriction on the entrepreneur's additional discount factor (eq. (39)), we have

$$\hat{z}=\hat{n}\frac{1}{\hat{q}\gamma}-\frac{\hat{c}^{e}}{\hat{q}} \tag{44}$$

Combining eqs. (43)and (44) yields:

$$\frac{\hat{c}^{e}}{\hat{n}}=\frac{1}{\gamma}-\beta \tag{45}$$

We have the two conditions from the financial contract

$$\hat{q}=\frac{1}{1-\Phi\left(\hat{\omega}\right)\mu+\phi\left(\hat{\omega}\right)\mu\frac{f(\hat{\omega})}{f'(\hat{\omega})}} \tag{46}$$

And

$$\hat{\imath}=\frac{1}{1-\hat{q}\left(1-\Phi\left(\hat{\omega}\right)\mu-f\left(\hat{\omega}\right)\right)}\hat{n} \tag{47}$$

Finally, we have the resource constraint:

$$\hat{c}+\hat{c}^{e}+\hat{\imath}=\hat{k}^{\alpha}\hat{h}^{1-\alpha} \tag{48}$$

The eight equations $(40),(41),(42),(43),(44),(46),(47),(48)$ are insufficient to find the nine unknowns. However, the risk premium, denoted as ζ, is defined by the following

$$\hat{q}\hat{\omega}\frac{\hat{\imath}}{\hat{\imath}-\hat{n}}=\zeta \tag{49}$$

But we also know (from eq.(47) that

$$\frac{\hat{n}}{\hat{\imath}}=1-\hat{q}\left(1-\Phi\left(\hat{\omega}\right)\mu-f\left(\hat{\omega}\right)\right)=1-\hat{q}g\left(\hat{\omega}\right)$$

Rearranging eq.(49) yields:

$$\frac{\hat{q}\hat{\omega}}{\zeta}=1-\frac{\hat{n}}{\hat{\imath}}$$

substituting from the previous expression yields

$$\hat{\omega}=\zeta g\left(\hat{\omega}\right) \tag{50}$$

Let κ = bankruptcy rate – this observable also provides another condition on the distribution. That is, we require:

$$\Phi\left(\hat{\omega}\right)=\kappa \tag{51}$$

The two equations eq.(50) and eq. (51) can be solved for the two unknowns - $(\hat{\omega},\sigma)$. By varying the bankruptcy rate and the risk premium, we can determine different levels of uncertainty $(\sigma)$and the cutoff point $(\hat{\omega})$.

Note that the price of capital in steady-state, is a function of $(\hat{\omega},\sigma)$ as determined by eq. (46). The other preference parameter, γ is then determined by eq. (39). Once this is determined, the remaining unknowns: $\left(\hat{c}, \hat{c}^e, \hat{h}, \hat{\imath}, \hat{k}, \hat{z}, \hat{n}\right)$ are determined by eqs. $(40), (41), (42), (43), (45), (47), (48)$.

Finally, we note that the parameter η does not play a role in the characteristics of equilibrium and, in particular, the behavior of aggregate consumption. This can be seen by first defining aggregate consumption:

$$(1-\eta)\,\tilde{c}_t + \eta c_t^e = C_t^A$$

Dividing by η and using the earlier definitions:

$$c_t + c_t^e = c_t^A \tag{52}$$

Since the policy rules for household and entrepreneurial consumption are defined as the percentage deviations from steady-state, aggregate consumption will be similarly defined (and note that since $c_t^A = \frac{1}{\eta} C_t^A$, percentage deviations of aggregate consumption and scaled aggregate consumption are identical). Using an asterisk to denote percentage deviations from steady-state, we have:

$$\frac{\hat{c}}{\hat{c}+\hat{c}^e} c_t^* + \frac{\hat{c}^e}{\hat{c}+\hat{c}^e} c_t^{e*} = c_t^{A*} \tag{53}$$

It is this equation that is used to analyze the cyclical properties of aggregate consumption.

6 Data Appendix

Data Source for Table 1:

- Bankruptcy rates for the E.U. nations: Klapper (2001) Table 2. For the U.S. bankruptcy rate, see Carlstrom and Fuerst (1997).
- Risk Premium: Lending minus deposit rates. Source: European Central Bank. National Retail Interest Rates. 1995:4 - 2002:8

1. - Austria
     - Lending Rate; N4 Short-term loans to enterprises. "Loans to enterprises".
     - Deposit Rate; N8 Time deposits. "Saving deposits with maturity up to 12 months".
   - Ireland
     - Lending Rate; N4 Short-term loans to enterprises. "Overdrafts and term loans up to 1 year - AA rate/lending to firms".
     - Deposit Rate; N92 Savings accounts. "Clearing banks demand deposits IEP 25 000 to IEP 100 000 - enterprises".
   - Spain
     - Lending Rate; N4 Short-term loans to enterprises. "Variable rate; monthly reviewable".
     - Deposit Rate; N8 Time deposits. "Deposits with maturity over 1 up to 2 years".

- U.S. (Source: Carlstrom and Fuerst (1997))
  - Risk Premium: The average spread between the prime rate and the three-month commercial paper rate for the period April 1971 to June 1996.

Data Source for ACFs

All the European GDP per capita series are from the Datastream from 1960 to 2000. These are seasonally adjusted and are expressed in current U.S. dollars. The Datastream source codes are as follows:

- Austria: OEGDPH; Ireland: IRGDPH; Spain: ESGDPH; EMU11: EMGDPCR
- U.S.: GDP per capita is calculated using quarterly data for GDP total, Population over 16 and CPI from 1948:1 to 2002:1. Source: Federal Reserve Bank Data Bank.

Figure 1: Autocorrelation Functions for the U.S. and Selected EMU Countries' Output Growth

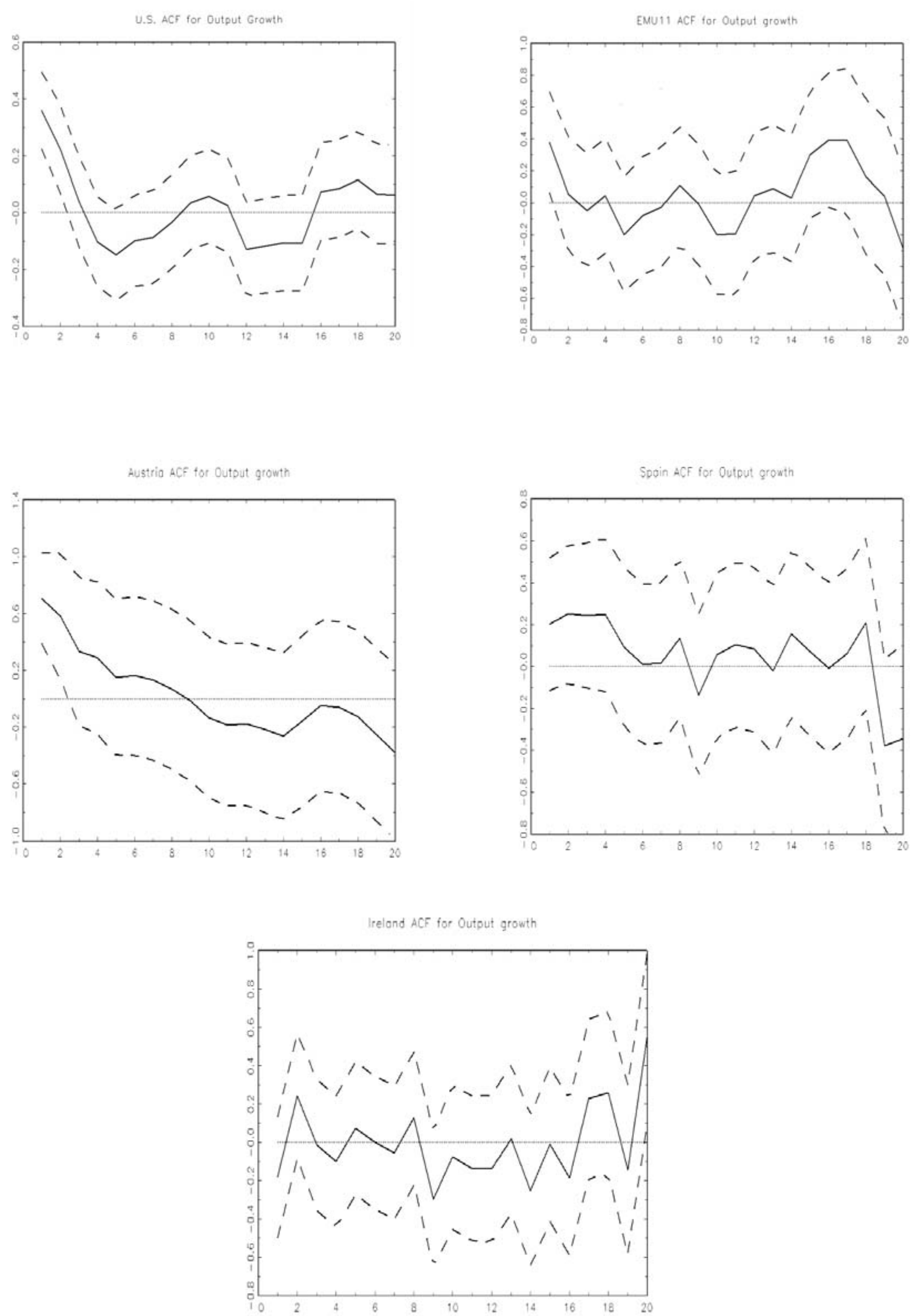


Figure 2: Response of Output to Productivity Shock

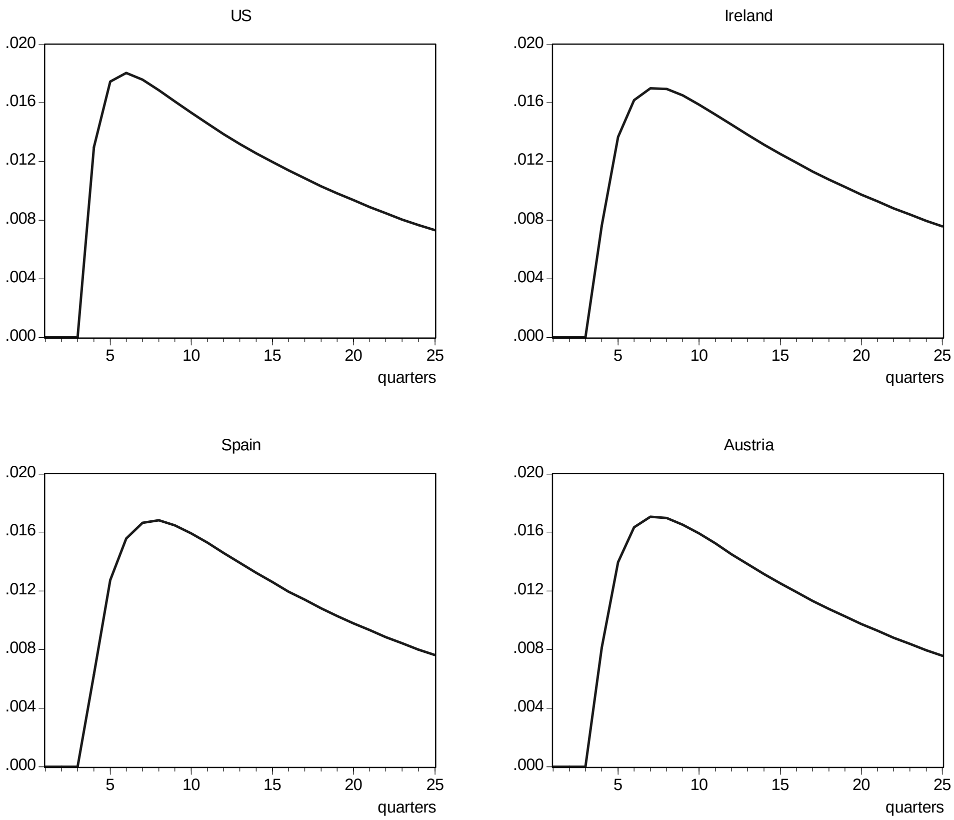


Figure 3: Response of Aggregate Consumption to Productivity Shock

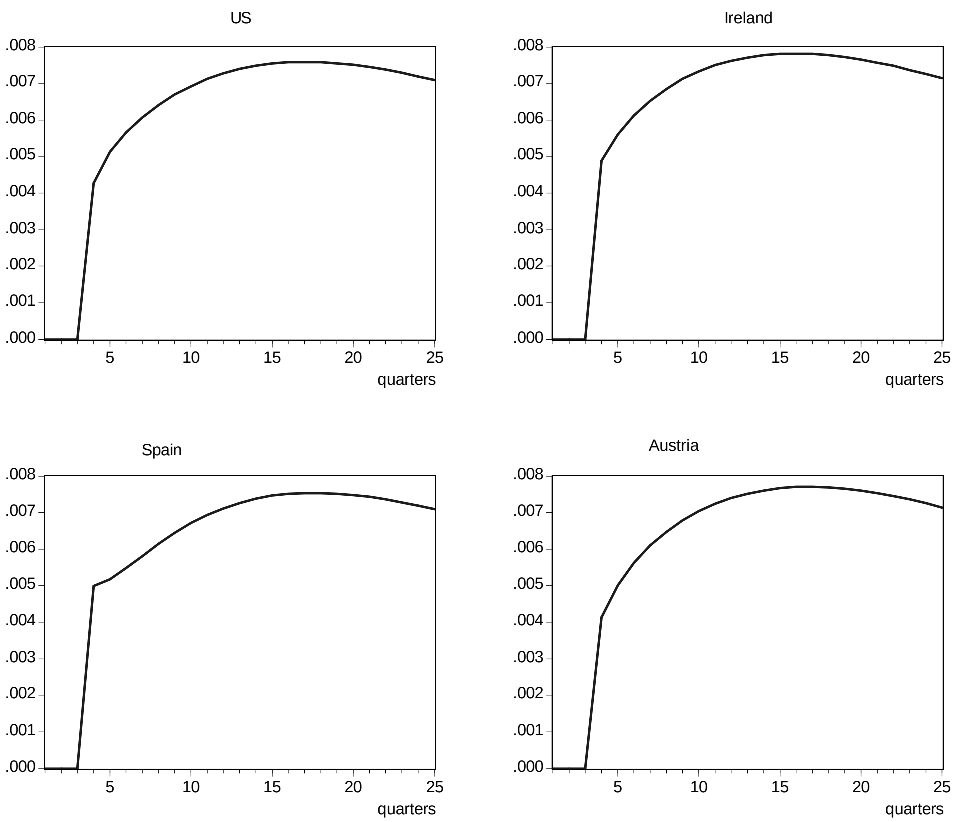


Figure 4: Response of Investment to Productivity Shock

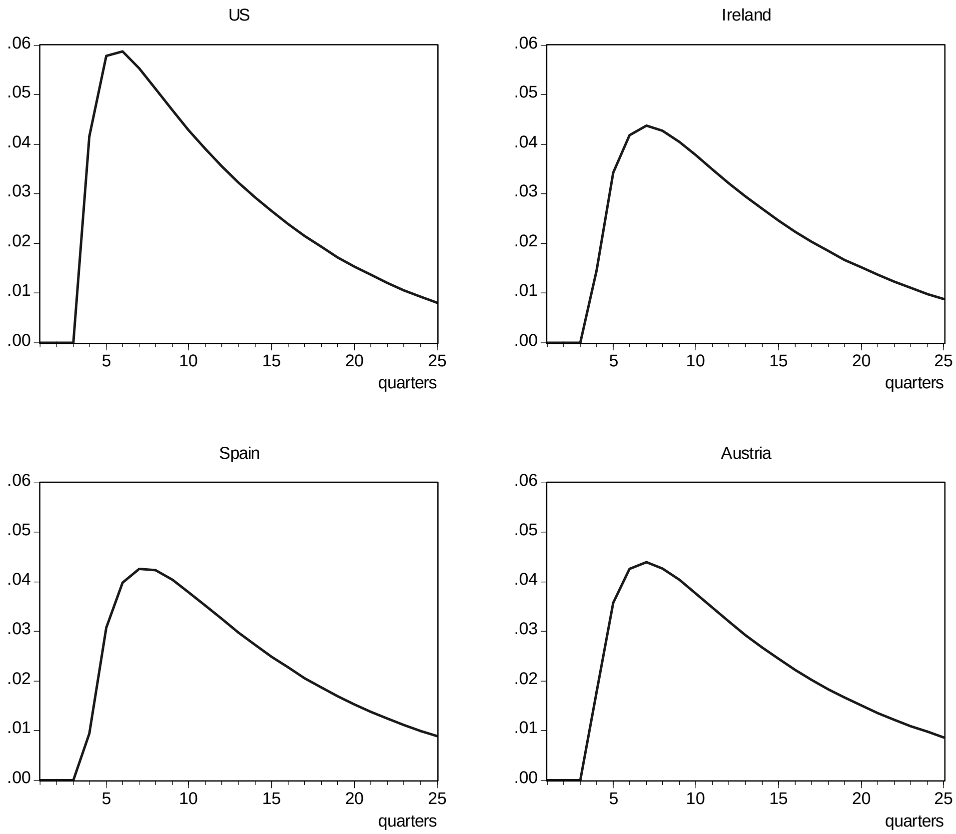


Figure 5: Response of Bankruptcy Rate to Productivity Shock

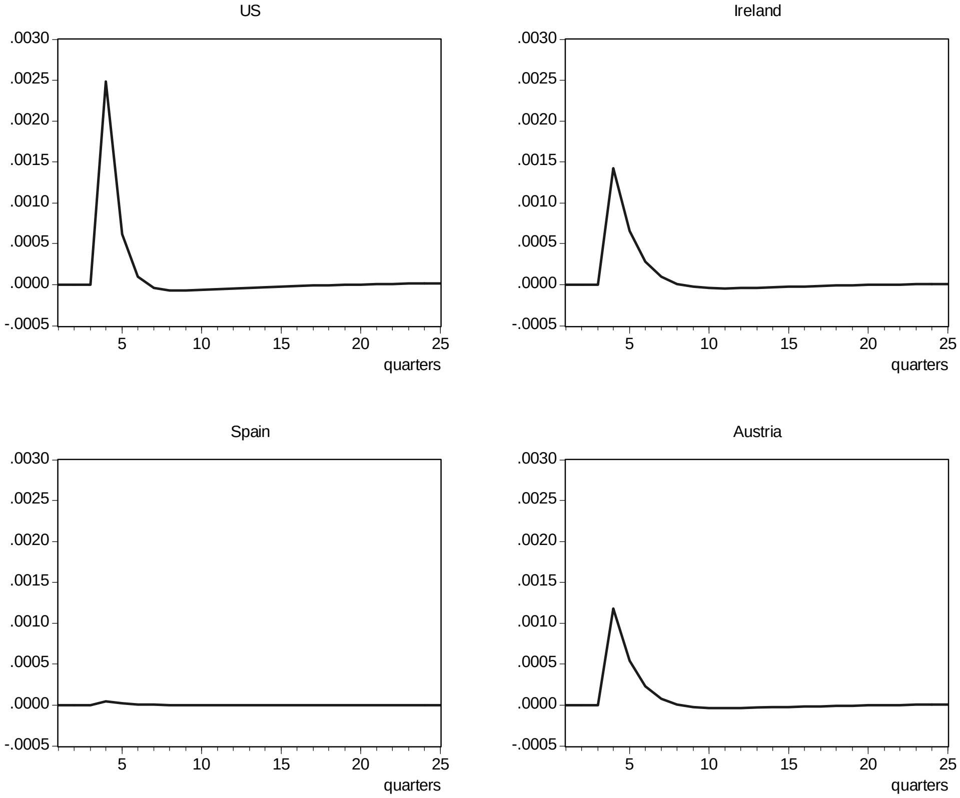


Figure 6: Response of Risk Premium to Productivity Shock

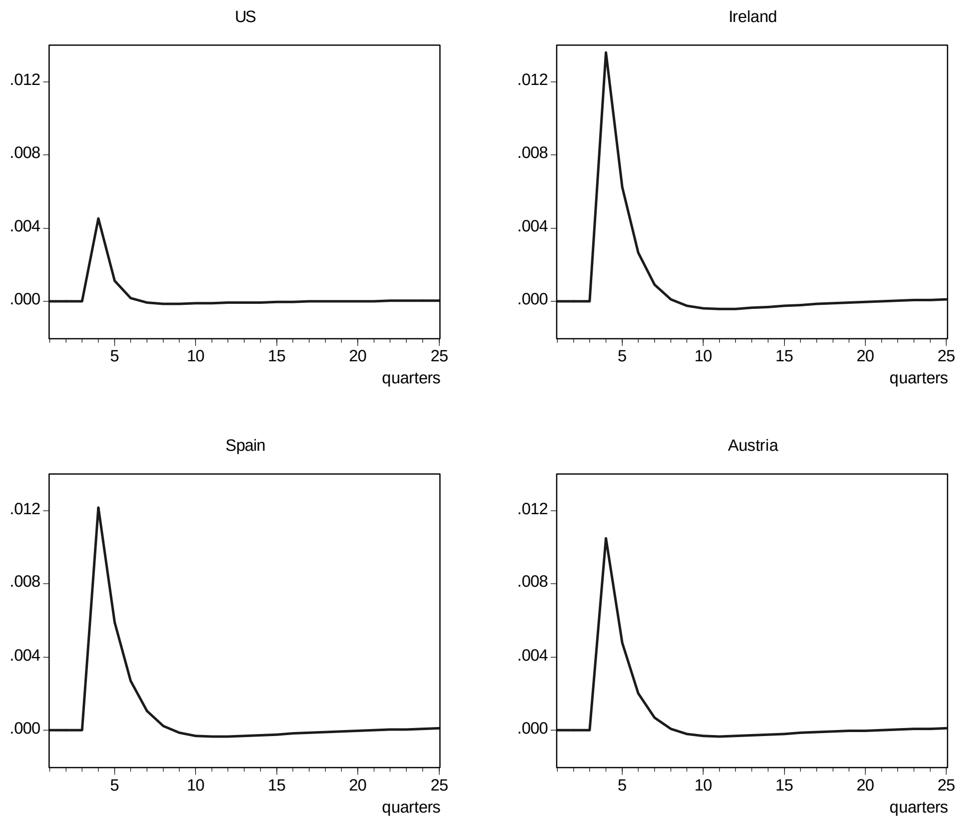
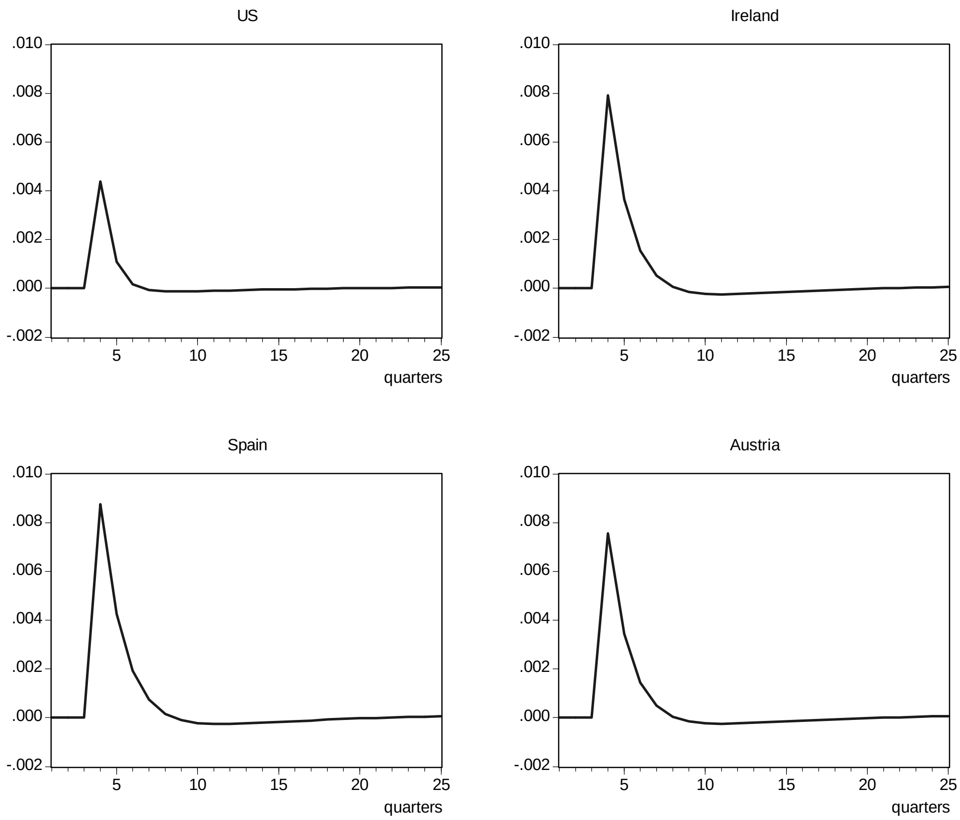


Figure 7: Response of Price of Capital to Productivity Shock



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NIESR	National Institute of Economic and Social Research, London, UK
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PRAXIS	Center for Policy Studies, Tallinn, Estonia
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