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ENTREPRENEURSHIP AND UNEMPLOYMENT: A NONLINEAR BIDIRECTIONAL CAUSALITY?

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Entrepreneurship and unemployment: A nonlinear bidirectional causality?

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Abstract

This paper tests the view that the relation between unemployment and entrepreneurship is dynamic and possibly nonlinear. It performs Granger-causality tests and STAR-EXT estimation to assess the causality direction and the nonlinear nature of the relation for a set of OECD countries. The results reveal a bidirectional and nonlinear relation between business creation and changes in unemployment.

Keywords: New firms; employment creation; causality; nonlinearities; STAR-EXT.

JEL Classification: J69, L26, M13

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Entrepreneurship and unemployment: A nonlinear bidirectional causality?

I. Introduction

Entrepreneurship is one of the main engines of growth in modern economies [e.g., Thurik, 2008]; as a consequence, its role in impacting unemployment is of utmost importance. Empirical studies have shown that small businesses have become more important over the past recent decades. During most part of the 20th century, however, large firms occupied the main role in the economy [e.g., Caves, 1982], when economies of scale seemed to be the decisive factor[1].

The evidence that the relative importance of small businesses was declining over time [Scherer, 1991] became a stylized fact. This triggered a massive and influential literature concerning small business in post-war developed economies to establish other stylized facts, such as: i) Small businesses are generally less efficient than larger firms [Pratten, 1971]; ii) Small business have lower level of employee compensation [Brown and Medoff, 1989]; iii) Small businesses are marginally innovative [Chandler, 1990].

This scenario changed in the last decades of the twentieth century due, among other factors, to economic instability, technological innovations and globalization. Economic activity moved away from large firms to small firms in the 1970's and 1980's [Carlsson, 1992; and Acs and Audretsch, 1993]. According to Carlsson (1992) globalization fostering greater competition, uncertainty and market fragmentation, on the one hand, and technological progress, on the other hand, played important roles in

[1] This helps explain the shift of Schumpeter's view of entrepreneurs. In his Theory of Economic Development, published in 1908, he emphasized creative destruction led by individual entrepreneurs, while in his Capitalism, Socialism and Democracy, published in 1942, he focuses on innovative activities by large firms, a process of creative accumulation. In Galbraith's famous book (1956) this is the world of big business that is balanced by big government and big labor.

this change. Brock and Evans (1989) identify four reasons for the change: increase of labor supply, changes in consumer tastes, relaxation of regulations and the fact that the world economy was under a creative destruction period.

Globalization has shifted comparative advantage of high cost location to knowledge-based activities with high cost transfer, leading to the re-emergence of the entrepreneurial economy [e.g., Audretsch and Thurik, 2000, 2001 and 2004]. Audretsch and Thurik (2007) characterize the entrepreneurial economy as an economy with greater flexibility, turbulence, diversity, creativity, and novelty.

In an entrepreneurial economy entrepreneurship is one of the engines of growth. As economic growth is linked to changes in unemployment, through the growth rate form of the Okun's law [e.g. Prachowny, 1993], one can safely assume that there is a relation between entrepreneurship and unemployment. However, what type of relationship is this? Should we expect that greater entrepreneurial activity leads to greater economic growth and, as a consequence, lower unemployment rates? In this case entrepreneurship causes a reduction in unemployment, and as a result there is an inverse relationship between them; more entrepreneurship, less unemployment.

It is important to stress that the economic growth channel as exposed above is just one of the possible ways to link entrepreneurship with unemployment. There are other alternatives, not necessarily opposed to the economic growth channel, worth noticing. The pioneering work of Oxenfeldt (1943), for example, extended Frank Knight's (1921) view that individuals choose between unemployment, self-employment and employment, by taking into account relative prices of these activities. In this sense, unemployed individuals facing low prospects of wage employment, turn to self-employment as the best alternative. Therefore, unemployment is positively related to business creation. Another approach to address the relationship is given by the Gibrat's law literature. The Gibrat's law says that firm growth is independent of size [e.g., Sutton, 1997], which implies that when the economy change from large corporations to small firms the unemployment rate should not change[2].

It is well known that the link between unemployment and entrepreneurship is a relevant empirical relationship that, so far, is characterized by ambiguity. Some studies have found that entrepreneurship and unemployment are inversely related, but others have come to the opposite conclusion, finding that unemployment is associated with greater entrepreneurial activities. For instance, Garofoli (1994) and Audretsch and Fritsch (1994) found that unemployment is negatively related to new-firm startups, while Highfield and Smiley (1987) and Evans and Leighton (1990) found that unemployment is positively associated with a greater propensity to start a new firm.

The ambiguity showed by the empirical work has led researchers to postulate that the relation between entrepreneurship and unemployment is dynamic, as in Audretsch et al. (2001). It also may be the case that the dynamic relation is nonlinear, possibly cyclical, as found by Faria et al. (2008). It is important to emphasize that the dynamic and nonlinear nature of the relationship does not necessarily contrast with the views exposed above; it may push the proponents of the above cited literature to consider the feedback mechanisms derived from their views on the relationship between entrepreneurship and unemployment.

This paper contributes to this line of research by assessing the Granger-causality between entrepreneurship and unemployment for a set of OECD countries. It also studies whether or not there is some nonlinear causality between them, based on a smooth transition autoregression with exogenous transition (STAR-EXT) estimation. The paper is organized as follows. The next section presents the Granger causality tests.

[2] For Geroski (1995) it is a stylized fact that smaller firms have higher growth rates than their larger counterparts.

The nonlinear modeling appears in section 3. Finally, section 4 presents the concluding remarks.

II. Granger causality results

The data for our empirical application consist of two variables; unemployment rates (u_t) and self employment (business ownership per labor force) (e_t). We have selected a small sample of OCDE countries in order to carry out the empirical analysis, i.e. Australia, Japan, United States, United Kingdom, Republic of Ireland, Germany, France, Italy and Spain, with annual observations from 1972 to 2004. The data have been obtained from the Comparative Entrepreneurship Data for International Analysis (COMPENDIA) data base.

First, we have applied the Ng and Perron (2001) unit root tests in order to analyze the order of integration of both variables. Ng and Perron (2001) propose several unit root tests that are modifications of existing ones in order to improve their performance, i.e. size and power, in particular in short sample sizes. The results indicate that both variables are unit root processes[3]. Note that if the variables are integrated processes, the variable business creation (the differential between actual business ownership and its past values) as well as the variation in unemployment are stationary. Therefore, the empirical analysis is going to rely on the estimation of a VAR model in first differences and testing for Granger causality.

Table 1 displays the results for the Granger causality test. The lag length has been selected using the Schwartz Information Criteria (SIC) from a maximum of 8 lags. In order to compute the variables of business creation $\Delta^i e_t = e_t - e_{t-i}$ and variation in unemployment $\Delta^i u_t = u_t - u_{t-i}$ we have used a time span *i* larger than one year, since

[3]Although the results have been omitted in the present paper, they are available upon request.

the impact of new startups on unemployment, and vice versa, is not instantaneous and it requires some time [Audretsch et al., 2001]. This means that for the new unemployed obtaining the necessary resources to open a new firm, and for new firms to grow enough in order to be able to hire new workers, it is necessary more than one year.

From table 1 it is possible to highlight the fact that for the countries analyzed, except for the UK[4], where we could not find any causality between unemployment variation and business for different spans of time, there is a causal relationship between business creation and variation in unemployment. It is noticeable that for some of the countries, such as Ireland, Germany, United States and Australia (probably the countries with the most dynamic labor markets from our sample), the null hypothesis of no causation is rejected in both directions, implying then that the direction of causality is bilateral. For the rest of the cases, we only find that unemployment variation cause business creation in Italy and Japan. Finally, in the case of France, the causation runs from entrepreneurship to unemployment.

INSERT TABLE 1 HERE

III. Nonlinearities in causation. Methodology and results

In this section, the analysis goes beyond the linear causal relationship in order to detect whether nonlinear effects are the underlying factors explaining causality and, therefore, the reason why Granger tests failed for some countries.

The existence of nonlinearities would mean that variation in unemployment rates (business creation) behaves in a different manner depending on the state given by business creation (variation in unemployment rates). This asymmetric behavior will be

[4]Result available upon request to the authors.

captured through the STAR-EXT model, a type of smooth transition (ST) specification. Thus, this paper investigates and assesses the performance of STAR-EXT models compared to that of linear specifications in reflecting the causation between unemployment and entrepreneurship.

The model

STs belong to the family of state-dependent models. The data generating process is a linear one that switches between a certain number of regimes according to some rule; the regime is characterized as a continuous function of a predetermined variable, so that interactions between variables, as well as intermediate states between the extreme regimes, are permitted. We choose this parameterization because it allows for a variety of dynamic behavior that a linear model cannot characterize in an appropriate way and, moreover, once the state is given, the model is locally linear and easy to interpret. See Granger and Teräsvirta (1993), Teräsvirta (1994, 1998) and van Dijk et al. (2002) for a further insight of STs.

The model to be used in this paper is a basic version of ST models: the smooth transition autoregression (STAR). This specification implies a univariate dynamic dependence and an endogenous regime determination. For this purpose, an exogenous transition is needed and the solution is given by the STAR-EXT models proposed in Cancelo and Mourelle (2005); these models are midway between STARs and general smooth transition regressions.

Suppose $\{y_t\}$ a stationary, ergodic process: the STAR-EXT model of order p with x_t the exogenous variable is defined as

$$y_t = \pi_0 + \sum_{i=1}^{p} \pi_i y_{t-i} + F(x_{t-d}) \left[\theta_0 + \sum_{i=1}^{p} \theta_i y_{t-i} \right] + u_t \qquad (1)$$

where $F(x_{t-d})$ is a transition function customarily bounded between 0 and 1 that makes the STAR-EXT coefficients vary between π_j and $\pi_j + \theta_j$ ($j = 0, ..., p$), respectively; d is the transition lag. The regime at each t is determined by the transition variable, x_{t-d}, and the associated value of $F(x_{t-d})$. In its basic version, the regime-switching STAR model considers two distinct regimes, corresponding to F=0 and F=1; the transition from one regime to the other is smooth over time, meaning that parameters in (1) gradually change with the state variable.

The STAR model links two linear components through F(.), so that connection features depend on the formulation for F, especially on whether it is odd or even. The odd case is usually represented by the logistic function:

$$F(x_{t-d}) = \frac{1}{1 + \exp[-\gamma(x_{t-d} - c)]} \quad , \qquad \gamma > 0 \qquad (2)$$

The resulting model is the Logistic STAR-EXT or LSTAR-EXT model, where $F(-\infty) = 0$ and $F(\infty) = 1$. The slope parameter γ defines the smoothness of the transition from one regime to the other: the greater it is the more rapid the change. The location parameter c indicates the threshold between the two regimes; here, $F(c) = 0.5$, so the regimes are associated with low and high values of x_{t-d} relative to c.

Second, the exponential function

$$F(x_{t-d}) = 1 - \exp\left[-\gamma(x_{t-d} - c)^2\right] \quad , \qquad \gamma > 0 \qquad (3)$$

provides the Exponential STAR-EXT (ESTAR-EXT) model. This even function implies $F(\pm\infty) = 1$ and $F(c) = 0$ for some finite c, defining the outer and the middle extreme regime, respectively.

The selection of the transition function is a key point for understanding nonlinearities since logistic and exponential models describe quite different types of (regime-switching) behavior. In the LSTAR-EXT model the extreme regimes are associated with x_{t-d} values far above or below c, where dynamics may be different; the ESTAR-EXT model suggests a rather similar dynamics in the extreme regimes, related to low and high x_{t-d} absolute values, while it can be different in the transition period.

Modeling procedure

The first step is to determine the linear model that would describe the evolution of variation of unemployment and business creation in the countries. We carry out an ordinary least squares estimation, considering a range of values for the lag order p from 1 to 6 (a sixth-order dynamics seems general enough for annual data); we use the Akaike Information Criterion (AIC) to select the proper number of lags in each case. To save space, linear models are not reported, but they are available from the authors upon request.

The next step is the specification and estimation of the STAR-EXT models for all countries; we regard the causality running from business creation to variation of unemployment and vice versa.

Traditionally, the modeling cycle for ST(A)R models has had its basis on reproducing Box and Jenkins (1970) iterative methodology with the development of the following stages: search for specification, estimation and evaluation of the model. There exists a well-established ST(A)R modeling strategy in the literature [Granger and Teräsvirta, 1993; Teräsvirta, 1994]. Nonetheless, the most recent empirical work does not follow this procedure in such a strict manner; it is argued that it is possible to develop valid nonlinear formulations that improve the fit of the linear ones by means of an extensive search of ST(A)R models (even if the null hypothesis of linearity is not rejected). This is the methodology considered in this paper.

We define several combinations of p, d and F(.): the transition lag varies from 0 to p and the transition function is permitted to be either logistic or exponential. As a result, a large number of potential models are specified; the one offering the best properties is selected. This process follows the one traced by Öcal and Osborn (2000), van Dijk et al. (2002) and Sensier et al. (2002), among others. It departs from the commonly used Teräsvirta's (1994) procedure in that lesser emphasis is laid on the early stages of the modeling process in exchange for attaching more importance to the evaluation of the finally proposed model, so that any possible inadequacy of the nonlinear model is expected to be unveiled at the evaluation stage.

STAR-EXT specifications are estimated by nonlinear least squares. The key point is the estimation of the slope parameter and the location parameter, as they can pose special problems like those reported in Teräsvirta (1994). Following the recommendations of this author, the argument of the transition function is scaled by dividing it by the standard deviation of the dependent variable in the logistic case and by the variance in the exponential one. We have tried several values for γ and a value close to the sample mean of the transition variable for c.

The best models are subject to further refinement. First, nonsignificant coefficients are excluded to conserve degrees of freedom; then, we simplify this first set of estimations through cross-parameter restrictions in order to increase efficiency. We take 1.6 as the limit t-value for these coefficients.

Finally, several misspecification tests to validate the proposed models are developed. We consider the test of no autoregressive conditional heteroskedasticity with four lags (ARCH) and the test of business cycle heteroskedasticity (BCH) posed by Öcal & Osborn (2000). There are three tests specially derived for smooth transition models in Eitrheim & Teräsvirta (1996) that we also report: the test of residual serial independence against process of different orders, although just the correspondent to order 6 is shown (AUTO); the test of no remaining nonlinearity in the residuals, computed for several values of the transition lag under the alternative but only the one minimizing the p-value of the tests is displayed (NL); the test of parameter constancy that allows for monotonically changing parameters under the alternative (PC).

Likewise, we also pay attention to the significance of the estimated coefficients, the characteristics of the transition function and the results of the following diagnostic statistics: the residual standard error (s), the adjusted determination coefficient ($\overline{R}^2$) and the variance ratio of the residuals from the nonlinear model and the best linear specification (s^2/s^2_L).

Empirical results

The extensive search of STAR-EXT models generates multiple STR specifications, although parameter convergence is not attained in some of them. The estimation process is developed for both directions of causality: from entrepreneurship to unemployment and vice versa. Beginning with the first one, empirical evidence reveals that business creation causes nonlinear effects on unemployment variation. This behavior is reflected in the STAR-EXT models presented in table 2, together with some diagnostic and evaluation statistics.

INSERT TABLE 2 HERE

In addition to this, the linearity hypothesis is tested against the estimated STAR-EXT models; table 3 displays the p-values of the F tests and evidence of nonlinear behavior is founded in all countries at a 0.10 significance level (United Kingdom is on the edge).

INSERT TABLE 3 HERE

The estimated regression coefficients are significant and above 1 in several cases, reflecting a considerable dynamism in the variation of unemployment; lag order p is moderate, so recent history of unemployment variation has effects on its current state for a (reasonable) long time. The transition from one regime to the other is not very fast and location parameter values are reasonably close to business creation sample means in most of the countries, so that a near equal distribution between the left and the right sides of the exponential function is expected. Italy clearly shows the opposite case, with the majority of the observations lying to the right of c; therefore, this exponential function in practice behaves as a logistic one.

There is no evidence of misspecification in the models, so they seem to be adequate. A fact to emphasize is the high explanatory power of the nonlinear models compared to the linear autoregressions, according to the variance ratios: the STAR-EXT model explains 14% to 61% of the residual variance of the best linear autoregression in all nine countries.

In short, variation in unemployment displays an asymmetric response depending on how business creation evolves. As the transition between regimes is exponential in all countries (see figure 1), the dynamics of variation in unemployment rates are similar when business creation is either very high or very low (outer regime), but different for an "intermediate" situation, that is, close to its mean (middle regime).

INSERT FIGURE 1 HERE

The fact of mainly having encountered exponential transitions may be related to the dynamic interaction existent between entrepreneurship and unemployment, described by limit cycles, as Faria et al. (2008) prove. Thus, for instance, a state of severe business creation needs hiring workers (reduction in unemployment), but a greater competition is also generated, leading to a smaller firm creation and to a potential increase in unemployment; the opposite situation takes place for a poor business creation, where the result may also be either an increase or a decrease in unemployment. These situations would correspond to the outer regime, where we appreciate rather similar dynamics in unemployment variation. Different dynamics arises in the middle regime: the growth in unemployment behaves in a different manner when business creation is near its average value.

Information about the local dynamic properties of the estimated nonlinear models can be obtained from the roots of the characteristic polynomials associated to them. In this paper, we compute the roots for the two extreme values of the transition function, F=0 and F=1; in order to save space, table 4 only displays the root with the highest modulus that is determining the long-run behavior of the series within each regime, i. e., the dominant root.

INSERT TABLE 4 HERE

The estimated models are globally stationary although locally unstable in five over nine countries. Australia, United States, Ireland, France and Japan show explosive roots related to the middle regime, so that variations in unemployment pass this regime rapidly in their way up or down, being stable for outstanding phases of business creation. In the rest of the countries the models are always stable.

Turning now to the causation running from unemployment to entrepreneurship, empirical evidence confirms again that business creation dynamics change with the state of variation in unemployment rates in the nine countries. This nonlinear behavior is described by the STAR-EXT models displayed in table 5. We confirm the asymmetric evolution looking at the p-values of the F linearity tests at a 0.10 significance level in table 6; linearity rejections are stronger for this direction of causality.

INSERT TABLE 5 HERE

INSERT TABLE 6 HERE

As well as unemployment, business creation has reasonably long univariate dynamics, however, contrary to what happened in the previous models, STAR-EXTs behave now as threshold specifications in the majority of the countries (see the mainly great values of gamma): business creation reacts rapidly to changes in unemployment variation, while we showed that the opposite response took longer time. This fact might be seen as an indicator of entrepreneurial initiative.

The evaluation of the fitted models proves to be acceptable. As in the opposite direction of causality, STAR-EXT models display an outstanding explanatory power: they can explain 24% to 67% of the residual variance of the best linear specification in all nine countries.

Once more, all the models are exponential except for one (see figure 2). Business creation responses to variations in unemployment are asymmetric, depending on whether unemployment is undergoing a great positive or negative increase (outer regime), or its values are within intermediate ones (middle regime); the valid model is a linear (different) one in each of both regimes. The logic behind the exponential transition has been remarked for business creation; in the current case, the existence of an "unemployment-entrepreneurship" cycle would make that a positive or negative intense growth in unemployment finally causes either less or more unemployment.

INSERT FIGURE 2 HERE

The analysis of business creation local dynamics reveals the way it evolves over the phases of unemployment variation. By observing table 7 we appreciate explosive roots in the middle regime in seven of the eight exponential models: business creation passes quickly the stages of usual variation in unemployment towards the stable ones of an important decrease or increase in unemployment.

INSERT TABLE 7 HERE

The facts of having discovered high values for the slope parameter, as well as explosive roots in the middle regime of most exponential models, may be reflecting the dynamism of the labor market.

In conclusion, we have demonstrated that unemployment variation causes business creation (and vice versa) in a nonlinear way in all countries of our sample. Consequently, we are now able to explain why some countries did not show a linear causality either in one direction (France, Italy and Japan) or both directions (United Kingdom): our variables display asymmetric reactions to each other that can only be described in a nonlinear framework.

IV. Conclusions

There are different ways to relate unemployment and entrepreneurship. The economic growth channel, for example, postulates that in modern economies entrepreneurship is one of the main engines of economic growth. In this sense, entrepreneurship by stimulating growth leads to a reduction in unemployment. Therefore there is a causality link that runs from entrepreneurship to unemployment, and the relation is negative. Alternative views, not necessarily opposed to the economic growth channel, may postulate different types of relation between unemployment and entrepreneurship. The Knight-Oxenfeldt view based on individual choices between unemployment, self-employment and employment, for example, favors the idea that causality runs from unemployment to entrepreneurship in a positive way, since unemployed individuals facing low prospects of wage employment, turn to self-employment as the best available choice. Another view based in the Gibrat's law, which sustains that firm growth is independent of size, implies that entrepreneurship may have little impact, if any, on unemployment. Recent literature goes one step further, claiming that the relation between unemployment and entrepreneurship is intrinsically dynamic, and possibly, nonlinear. According to this view, it is possible that they cause each other in a nonlinear way.

This paper follows the latter line of research and performs Granger-causality tests and STAR-EXT estimation to assess the causality direction and the nonlinear nature of the relation between unemployment and business creation for a set of OECD countries.

The Granger-causality tests show that there is bidirectional causality between unemployment variation and entrepreneurship for the countries that have the most flexible labor markets in our sample, i.e. Ireland, Germany, United States and Australia. Unemployment variation causes business creation in Italy and Japan, and for France, the causation runs from entrepreneurship to unemployment.

The empirical evidence from the STAR-EXT estimation reveals that unemployment variation causes business creation (and vice versa) in a nonlinear way in all countries of our sample. Business creation reacts rapidly to changes in unemployment variation, while the opposite response takes longer time. It is important to stress that the nonlinear models have higher explanatory power than the linear autoregression models.

The results of the STAR-EXT estimation explain why some countries did not show a linear causality either in one direction (France, Italy and Japan) or both directions (United Kingdom): our variables display asymmetric reactions to each other that can only be described in a nonlinear framework.

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TABLE 1

Granger causality test

Country	H_0	i	p-value
Ireland	$\Delta^i u_t \nrightarrow \Delta^i e_t$	3	0.09
	$\Delta^i e_t \nrightarrow \Delta^i u_t$	3	0.02
France	$\Delta^i u_t \nrightarrow \Delta^i e_t$	4	0.64
	$\Delta^i e_t \nrightarrow \Delta^i u_t$	4	0.06
Italy	$\Delta^i u_t \nrightarrow \Delta^i e_t$	4	0.07
	$\Delta^i e_t \nrightarrow \Delta^i u_t$	4	0.50
Germany	$\Delta^i e_t \nrightarrow \Delta^i u_t$	2	0.01
	$\Delta^i u_t \nrightarrow \Delta^i e_t$	3	0.04
Spain	$\Delta^i u_t \nrightarrow \Delta^i e_t$	2	0.11
	$\Delta^i e_t \nrightarrow \Delta^i u_t$	2	0.02
United States	$\Delta^i u_t \nrightarrow \Delta^i e_t$	2	0.01
	$\Delta^i e_t \nrightarrow \Delta^i u_t$	2	0.07
Japan	$\Delta^i u_t \nrightarrow \Delta^i e_t$	3	0.08
	$\Delta^i e_t \nrightarrow \Delta^i u_t$	3	0.56
Australia	$\Delta^i u_t \nrightarrow \Delta^i e_t$	2	0.00
	$\Delta^i e_t \nrightarrow \Delta^i u_t$	2	0.07

TABLE 2

Estimated STAR-EXT models for variation in unemployment

AUSTRALIA

$$\Delta u_t = \underset{(0.41)}{0.56} + \underset{(0.65)}{1.80}\,\Delta u_{t-1} - \underset{(0.46)}{1.18}\,\Delta u_{t-2}$$
$$+\left(-\underset{(0.56)}{0.95} - \underset{(0.65)}{1.80}\,\Delta u_{t-1} + \underset{(0.59)}{0.81}\,\Delta u_{t-2} + \underset{(0.35)}{0.52}\,\Delta u_{t-3} + \underset{(0.24)}{0.04}\,\Delta u_{t-5}\right)$$
$$\times\left[1-\exp\left\{-\underset{(0.81)}{1.22}\times 42967.89\left(\Delta e_{t-4} + \underset{(0.0005)}{0.0002}\right)^2\right\}\right] + a_t$$

s=0.6396, $\overline{R}^2$=0.44, s^2/s^2_L=0.56, ARCH=0.99 (0.44), BCH=0.07 (0.79), AUTO=0.78 (0.56), NL=8.81 (0.26), PC=1.44 (0.43)

FRANCE

$$\Delta u_t = \underset{(0.23)}{0.55} - \underset{(0.42)}{0.15}\,\Delta u_{t-1} + \underset{(0.44)}{0.81}\,\Delta u_{t-2} + \underset{(0.59)}{1.38}\,\Delta u_{t-3} - \underset{(0.74)}{2.64}\,\Delta u_{t-4}$$
$$+\left(-\underset{(0.38)}{0.24} + \underset{(0.58)}{0.84}\,\Delta u_{t-1} - \underset{(0.61)}{1.25}\,\Delta u_{t-2} - \underset{(0.74)}{1.74}\,\Delta u_{t-3} + \underset{(0.80)}{3.00}\,\Delta u_{t-4}\right)$$
$$\times\left[1-\exp\left\{-\underset{(1.34)}{2.84}\times 444643.64\left(\Delta e_{t-1} + \underset{(0.0001)}{0.0019}\right)^2\right\}\right] + a_t$$

s=0.4291, $\overline{R}^2$=0.43, s^2/s^2_L=0.48, ARCH=0.51 (0.73), BCH=0.25 (0.62), AUTO=2.54 (0.12), NL=1.80 (0.21), PC=2.38 (0.15)

GERMANY

$$\Delta u_t = -\underset{(0.22)}{0.27} + \underset{(0.25)}{1.09}\,\Delta u_{t-1} - \underset{(0.16)}{0.51}\,\Delta u_{t-2} + \left(\underset{(0.41)}{1.19} - \underset{(0.25)}{1.09}\,\Delta u_{t-1}\right)$$
$$\times\left[1-\exp\left\{-\underset{(0.45)}{0.83}\times 263829.76\left(\Delta e_{t-1} + \underset{(0.0003)}{0.0003}\right)^2\right\}\right] + a_t$$

s=0.5490, $\overline{R}^2$=0.46, s^2/s^2_L=0.86, ARCH=1.17 (0.35), BCH=0.01 (0.92), AUTO= 1.27 (0.32), NL=1.86 (0.14), PC=0.40 (0.87)

IRELAND

$$\Delta u_t = \underset{(0.72)}{0.29} - \underset{(0.68)}{0.98}\,\Delta u_{t-1} - \underset{(0.53)}{0.80}\,\Delta u_{t-3} + \underset{(0.46)}{0.43}\,\Delta u_{t-4}$$
$$+\left(-\underset{(0.80)}{0.51} + \underset{(0.68)}{1.75}\,\Delta u_{t-1} + \underset{(0.53)}{0.80}\,\Delta u_{t-3} - \underset{(0.51)}{0.62}\,\Delta u_{t-4}\right)$$
$$\times\left[1-\exp\left\{-\underset{(7.67)}{10.87}\times 29879.55\left(\Delta e_{t-5} + \underset{(0.0004)}{0.0004}\right)^2\right\}\right] + a_t$$

s=0.8056, $\overline{R}^2$=0.47, s^2/s^2_L=0.58, ARCH=0.38 (0.82), BCH=1.75 (0.20), AUTO=0.80 (0.55), NL=5.03 (0.04), PC=2.14 (0.20)

ITALY

$$\Delta u_t = -\underset{(0.17)}{0.31} + \underset{(0.34)}{1.10}\,\Delta u_{t-1} - \underset{(0.42)}{0.60}\,\Delta u_{t-2} + \underset{(0.26)}{0.41}\,\Delta u_{t-3}$$
$$+\left(\underset{(0.26)}{0.65} - \underset{(0.34)}{1.10}\,\Delta u_{t-1} + \underset{(0.63)}{1.05}\,\Delta u_{t-2} - \underset{(0.26)}{0.41}\,\Delta u_{t-3}\right)$$
$$\times\left[1-\exp\left\{-\underset{(0.65)}{0.79}\times 105274.33\left(\Delta e_{t-3} + \underset{(0.0009)}{0.0031}\right)^2\right\}\right] + a_t$$

s=0.3489, $\overline{R}^2$=0.43, s^2/s^2_L=0.70, ARCH=1.12 (0.37), BCH=0.70 (0.41), AUTO=1.20 (0.36), NL=1.41 (0.29), PC=0.99 (0.48)

JAPAN

$$\Delta u_t = -\underset{(0.15)}{0.22} + \underset{(0.34)}{0.42}\,\Delta u_{t-1} + \underset{(0.40)}{0.48}\,\Delta u_{t-2} + \underset{(0.65)}{1.86}\,\Delta u_{t-5}$$
$$+\left(\underset{(0.17)}{0.41} - \underset{(0.34)}{0.42}\,\Delta u_{t-1} - \underset{(0.40)}{0.48}\,\Delta u_{t-2} - \underset{(0.68)}{2.72}\,\Delta u_{t-5}\right)$$
$$\times\left[1-\exp\left\{-\underset{(1.25)}{2.86}\times 292539.05\left(\Delta e_{t-3} + \underset{(0.0002)}{0.0025}\right)^2\right\}\right] + a_t$$

s=0.1803, $\overline{R}^2$=0.46, s^2/s^2_L=0.66, ARCH=1.24 (0.33), BCH=0.004 (0.95), AUTO=0.44 (0.78), NL=2.83 (0.10), PC=1.85 (0.21)

SPAIN

$$\Delta u_t = -\underset{(0.32)}{0.61} + \underset{(0.17)}{0.88}\,\Delta u_{t-1} - \underset{(0.28)}{0.49}\,\Delta u_{t-2}$$
$$+\left(\underset{(0.48)}{1.24} + \underset{(0.28)}{0.49}\,\Delta u_{t-2} - \underset{(0.17)}{0.23}\,\Delta u_{t-4}\right)$$
$$\times\left[1-\exp\left\{-\underset{(1.11)}{1.13}\times 102320.79\left(\Delta e_{t-3} - \underset{(0.0009)}{0.0005}\right)^2\right\}\right] + a_t$$

s=0.6911, $\overline{R}^2$=0.67, s^2/s^2_L=0.69, ARCH=0.17 (0.95), BCH=0.21 (0.65), AUTO=2.11 (0.14), NL=2.17 (0.17), PC=0.99 (0.50)

UNITED KINGDOM

$$\Delta u_t = \underset{(0.41)}{0.71} + \underset{(0.11)}{0.48}\,\Delta u_{t-1} - \underset{(0.30)}{0.66}\,\Delta u_{t-3}$$
$$+\left(-\underset{(0.50)}{0.90} + \underset{(0.11)}{0.48}\,\Delta u_{t-1} - \underset{(0.35)}{0.73}\,\Delta u_{t-2} + \underset{(0.44)}{1.11}\,\Delta u_{t-3}\right)$$
$$\times\left[1-\exp\left\{-\underset{(2.84)}{2.88}\times 78140.99\left(\Delta e_{t-3} - \underset{(0.0006)}{0.0002}\right)^2\right\}\right] + a_t$$

s=0.7415, $\overline{R}^2$=0.46, s^2/s^2_L=0.74, ARCH=0.37 (0.83), BCH=2.52 (0.12), AUTO=0.63 (0.65), NL=29.26 (0.14), PC=0.83 (0.63)

UNITED STATES

$$\Delta u_t = \underset{(1.51)}{1.79} + \underset{(0.85)}{1.59}\,\Delta u_{t-1} + \underset{(1.07)}{1.30}\,\Delta u_{t-2} + \underset{(0.69)}{0.80}\,\Delta u_{t-4}$$
$$+ \left(-\underset{(1.50)}{2.08} - \underset{(0.85)}{1.59}\,\Delta u_{t-1} - \underset{(1.07)}{1.68}\,\Delta u_{t-2} - \underset{(0.69)}{1.60}\,\Delta u_{t-4} + \underset{(0.12)}{0.01}\,\Delta u_{t-5} \right)$$
$$\times \left[1 - \exp\left\{ -\underset{(5.79)}{7.19} \times 240368\ .32 \left(\Delta e_t - \underset{(0.0002)}{0.0004} \right)^2 \right\} \right] + a_t$$

s=0.4156, $\overline{R}^2$=0.62, s^2/s^2_L=0.39, ARCH=0.76 (0.56), BCH=4.34 (0.05), AUTO=4.31 (0.03), NL=5.17 (0.05), PC=0.72 (0.70)

Notes: Δu_t (Δe_t) denotes variation in unemployment (business creation). Values under regression coefficients are standard errors of the estimates; s is the residual standard error; $\overline{R}^2$ the adjusted determination coefficient; s^2/s^2_L is the variance ratio of the residuals from the nonlinear model and the best linear AR selected with AIC; ARCH is the statistic of no ARCH based on four lags; BCH is a business cycle heteroskedasticity test; AUTO is the test for residual autocorrelation of order 4; NL is the test for no remaining nonlinearity; PC is the parameter constancy test. Numbers in parentheses after values of ARCH, BCH, AUTO, NL and PC are p-values.

TABLE 3

Linearity tests against STAR-EXT models for variation in unemployment: p-values

Country (lag order)	
Australia (p=6)	0.0106
France (p=4)	0.0630
Germany (p=2)	0.0374
Ireland (p=5)	0.0141
Italy (p=3)	0.0965
Japan (p=5)	0.0099
Spain (p=4)	0.0072
United Kingdom (p=5)	0.1072
United States (p=5)	0.0007

TABLE 4

Local dynamics of the models for variation in unemployment: dominant roots in each regime

Country	Regime (value of F)	Root	Modulus
Australia	Middle (F=0)	0.8987 ± 0.6109i	1.09
	Outer (F=1)	-0.3270 ± 0.8063i	0.87
France	Middle (F=0)	-1.0588 ± 0.9760i	1.44
	Outer (F=1)	0.3763 ± 0.8628i	0.94
Germany	Middle (F=0)	0.5433 ± 0.4659i	0.72
	Outer (F=1)	0 ± 0.7157i	0.72
Ireland	Middle (F=0)	-1.4798	1.48
	Outer (F=1)	0.7157 ± 0.3713i	0.81
Italy	Middle (F=0)	0.9289	0.93
	Outer (F=1)	0.6701	0.67
Japan	Middle (F=0)	1.3458	1.35
	Outer (F=1)	-0.9694	0.97
Spain	Middle (F=0)	0.4385 ± 0.5501i	0.70
	Outer (F=1)	0.7771 ± 0.3594i	0.86
United Kingdom	Middle (F=0)	0.6101 ± 0.7250i	0.95
	Outer (F=1)	0.7765	0.78
United States	Middle (F=0)	2.2437	2.24
	Outer (F=1)	-0.5961 ± 0.7342i	0.95

TABLE 5

Estimated STAR-EXT models for business creation

AUSTRALIA

$$\Delta e_t = -\underset{(0.002)}{0.003} - \underset{(0.36)}{0.59}\,\Delta e_{t-1} + \left(\underset{(0.002)}{0.007} + \underset{(0.36)}{0.59}\,\Delta e_{t-1} + \underset{(0.28)}{0.54}\,\Delta e_{t-4}\right) \times \left[1 + \exp\left\{-\underset{(2.69)}{3.78} \times 0.96\left(\Delta u_{t-2} - \underset{(0.2997)}{0.3577}\right)\right\}\right]^{-1} + a_t$$

s=0.0032, $\overline{R}^2$=0.35, s^2/s^2_L=0.63, ARCH=0.92 (0.47), BCH=0.20 (0.65), AUTO=0.76 (0.57), NL=5.96 (0.01), PC=0.86 (0.58)

FRANCE

$$\Delta e_t = \underset{(0.0022)}{0.0007} + \underset{(0.11)}{0.22}\,\Delta e_{t-1} + \underset{(0.86)}{1.52}\,\Delta e_{t-2} - \underset{(0.18)}{0.27}\,\Delta e_{t-4} + \left(-\underset{(0.0023)}{0.0022} + \underset{(0.11)}{0.22}\,\Delta e_{t-1} - \underset{(0.86)}{1.52}\,\Delta e_{t-2}\right) \times \left[1 - \exp\left\{-\underset{(2.04)}{2.98} \times 1.94\left(\Delta u_{t-2} - \underset{(0.0889)}{0.7889}\right)^2\right\}\right] + a_t$$

s=0.0009, $\overline{R}^2$=0.32, s^2/s^2_L=0.76, ARCH=0.81 (0.53), BCH=0.26 (0.61), AUTO=3.22 (0.05), NL=2.32 (0.12), PC=1.93 (0.15)

GERMANY

$$\Delta e_t = -\underset{(0014)}{0.0022} + \underset{(0.63)}{1.07}\,\Delta e_{t-1} + \underset{(1.21)}{2.64}\,\Delta e_{t-4} - \underset{(1.80)}{3.43}\,\Delta e_{t-5} + \left(\underset{(0.0014)}{0.0030} - \underset{(0.63)}{1.07}\,\Delta e_{t-1} + \underset{(0.15)}{0.31}\,\Delta e_{t-3} - \underset{(1.21)}{2.64}\,\Delta e_{t-4} + \underset{(1.80)}{3.43}\,\Delta e_{t-5}\right) \times \left[1 - \exp\left\{-\underset{(7.78)}{13.89} \times 1.53\left(\Delta u_{t-3} + \underset{(0.0435)}{0.0083}\right)^2\right\}\right] + a_t$$

s=0.0009, $\overline{R}^2$=0.57, s^2/s^2_L=0.49, ARCH=0.64 (0.64), BCH=3.68 (0.07), AUTO=0.55 (0.70), NL=99.82 (0.08), PC=0.58 (0.80)

IRELAND

$$\Delta e_t = \underset{(0.0034)}{0.0064} + \underset{(0.72)}{1.14}\,\Delta e_{t-4} + \left(-\underset{(0.0037)}{0.0114} - \underset{(0.20)}{0.35}\,\Delta e_{t-1} + \underset{(0.24)}{0.68}\,\Delta e_{t-2} - \underset{(0.77)}{1.64}\,\Delta e_{t-4}\right) \times \left[1 - \exp\left\{-\underset{(3.63)}{5.46} \times 0.46\left(\Delta u_{t-1} + \underset{(0.1428)}{0.1111}\right)^2\right\}\right] + a_t$$

s=0.0043, $\overline{R}^2$=0.34, s^2/s^2_L=0.60, ARCH=0.57 (0.69), BCH=2.26 (0.14), AUTO=1.31 (0.32), NL=10.24 (0.04), PC=0.79 (0.64)

ITALY

$$\Delta e_t = -\underset{(0.0016)}{0.0031} - \underset{(0.61)}{0.54}\,\Delta e_{t-1} - \underset{(0.71)}{1.87}\,\Delta e_{t-2} - \underset{(1.13)}{2.82}\,\Delta e_{t-3}$$
$$+\left(\underset{(0.0018)}{0.0030} + \underset{(0.68)}{0.65}\,\Delta e_{t-1} + \underset{(0.71)}{1.87}\,\Delta e_{t-2} + \underset{(1.15)}{3.25}\,\Delta e_{t-3}\right)$$
$$\times\left[1-\exp\left\{-\underset{(0.65)}{1.19}\times 3.37\left(\Delta u_t + \underset{(0.1072)}{0.5643}\right)^2\right\}\right] + a_t$$

s=0.0021, $\overline{R}^2$=0.27, s^2/s^2_L=0.75, ARCH=1.05 (0.40), BCH=0.89 (0.35), AUTO=1.09 (0.40), NL=2.55 (0.09), PC=0.46 (0.86)

JAPAN

$$\Delta e_t = \underset{(0.0023)}{0.0028} + \underset{(0.40)}{0.98}\,\Delta e_{t-2} + \underset{(0.44)}{0.58}\,\Delta e_{t-4}$$
$$+\left(-\underset{(0.0024)}{0.0065} + \underset{(0.28)}{0.52}\,\Delta e_{t-1} - \underset{(0.46)}{1.44}\,\Delta e_{t-2} - \underset{(0.27)}{0.36}\,\Delta e_{t-3} - \underset{(0.44)}{0.58}\,\Delta e_{t-4}\right)$$
$$\times\left[1-\exp\left\{-\underset{(2.16)}{3.22}\times 13.08\left(\Delta u_{t-2} + \underset{(0.0305)}{0.0735}\right)^2\right\}\right] + a_t$$

s=0.0013, $\overline{R}^2$=0.26, s^2/s^2_L=0.80, ARCH=1.88 (0.15), BCH=2.86 (0.10), AUTO=0.82 (0.54), NL=1.90 (0.25), PC=0.39 (0.92)

SPAIN

$$\Delta e_t = \underset{(0.0031)}{0.0059} + \underset{(0.69)}{1.04}\,\Delta e_{t-1} - \underset{(0.14)}{0.24}\,\Delta e_{t-2} + \underset{(0.57)}{1.64}\,\Delta e_{t-4}$$
$$+\left(-\underset{(0.0032)}{0.0095} - \underset{(0.73)}{1.58}\,\Delta e_{t-1} - \underset{(0.57)}{1.64}\,\Delta e_{t-4}\right)$$
$$\times\left[1-\exp\left\{-\underset{(1.57)}{3.53}\times 0.55\left(\Delta u_{t-4} - \underset{(0.1529)}{0.9861}\right)^2\right\}\right] + a_t$$

s=0.0016, $\overline{R}^2$=0.45, s^2/s^2_L=0.53, ARCH=1.44 (0.26), BCH=0.11 (0.74), AUTO=0.86 (0.51), NL=2.53 (0.32), PC=2.16 (0.16)

UNITED KINGDOM

$$\Delta e_t = \underset{(0.0012)}{0.0049} + \underset{(0.43)}{1.37}\,\Delta e_{t-2} - \underset{(0.14)}{0.18}\,\Delta e_{t-3}$$
$$+\left(-\underset{(0.0013)}{0.0054} + \underset{(0.16)}{0.50}\,\Delta e_{t-1} - \underset{(0.43)}{1.37}\,\Delta e_{t-2} - \underset{(0.13)}{0.37}\,\Delta e_{t-4}\right)$$
$$\times\left[1-\exp\left\{-\underset{(6.48)}{10.22}\times 0.77\left(\Delta u_t + \underset{(0.0576)}{0.1543}\right)^2\right\}\right] + a_t$$

s=0.0018, $\overline{R}^2$=0.66, s^2/s^2_L=0.33, ARCH=0.48 (0.75), BCH=4.40 (0.04), AUTO=0.24 (0.91), NL=2.10 (0.18), PC=0.27 (0.97)

UNITED STATES

$$\Delta e_t = -\underset{(0.0006)}{0.0009} + \underset{(0.38)}{1.09}\,\Delta e_{t-1} - \underset{(0.47)}{0.82}\,\Delta e_{t-2} + \underset{(0.26)}{0.28}\,\Delta e_{t-3}$$

$$+\left(\underset{(0.0009)}{0.0023} - \underset{(0.38)}{1.09}\,\Delta e_{t-1} + \underset{(0.67)}{1.58}\,\Delta e_{t-2} - \underset{(0.26)}{0.28}\,\Delta e_{t-3} - \underset{(0.52)}{0.66}\,\Delta e_{t-4}\right)$$

$$\times\left[1 - \exp\left\{-\underset{(1.49)}{1.69} \times 1.10\left(\Delta u_t + \underset{(0.1380)}{0.2611}\right)^2\right\}\right] + a_t$$

s=0.0014, $\overline{R}^2$=0.37, s^2/s^2_L=0.59, ARCH=0.26 (0.90), BCH=0.11 (0.74), AUTO=1.65 (0.23), NL=2.11 (0.18), PC=7.83 (0.002)

Notes: Δu_t (Δe_t) denotes variation in unemployment (business creation). Values under regression coefficients are standard errors of the estimates; s is the residual standard error; $\overline{R}^2$ the adjusted determination coefficient; s^2/s^2_L is the variance ratio of the residuals from the nonlinear model and the best linear AR selected with AIC; ARCH is the statistic of no ARCH based on four lags; BCH is a business cycle heteroskedasticity test; AUTO is the test for residual autocorrelation of order 4; NL is the test for no remaining nonlinearity; PC is the parameter constancy test. Numbers in parentheses after values of ARCH, BCH, AUTO, NL and PC are p-values.

TABLE 6

Linearity tests against STAR-EXT models for business creation: p-values

Country (lag order)	
Australia (p=4)	0.0004
France (p=4)	0.0263
Germany (p=5)	0.0011
Ireland (p=4)	0.0093
Italy (p=3)	0.0281
Japan (p=4)	0.0479
Spain (p=5)	0.0037
United Kingdom (p=4)	0.0000
United States (p=4)	0.0152

TABLE 7

Local dynamics of the models for business creation: dominant roots in each regime

Country	Regime (value of F)	Root	Modulus
Australia	Lower (F=0)	-0.5893	0.59
	Upper (F=1)	-0.8564	0.86
France	Middle (F=0)	1.2767	1.28
	Outer (F=1)	0.6376 ± 0.4891i	0.80
Germany	Middle (F=0)	-1.3038	1.30
	Outer (F=1)	-0.3400 ± 0.5889i	0.68
Ireland	Middle (F=0)	-1.0326	1.03
	Outer (F=1)	-0.8195 ± 0.3577i	0.89
Italy	Middle (F=0)	0.2886 ± 1.5598i	1.59
	Outer (F=1)	0.7929	0.79
Japan	Middle (F=0)	1.1825	1.18
	Outer (F=1)	0.4692 ± 0.7962i	0.92
Spain	Middle (F=0)	1.4340	1.43
	Outer (F=1)	-0.2698 ± 0.4102i	0.49
United Kingdom	Middle (F=0)	-1.2321	1.23
	Outer (F=1)	0.7080 ± 0.6024i	0.93
United States	Middle (F=0)	0.2810 ± 0.6668i	0.72
	Outer (F=1)	-0.7716 ± 0.4644i	0.90

FIGURE 1

Estimated transition functions for variation in employment

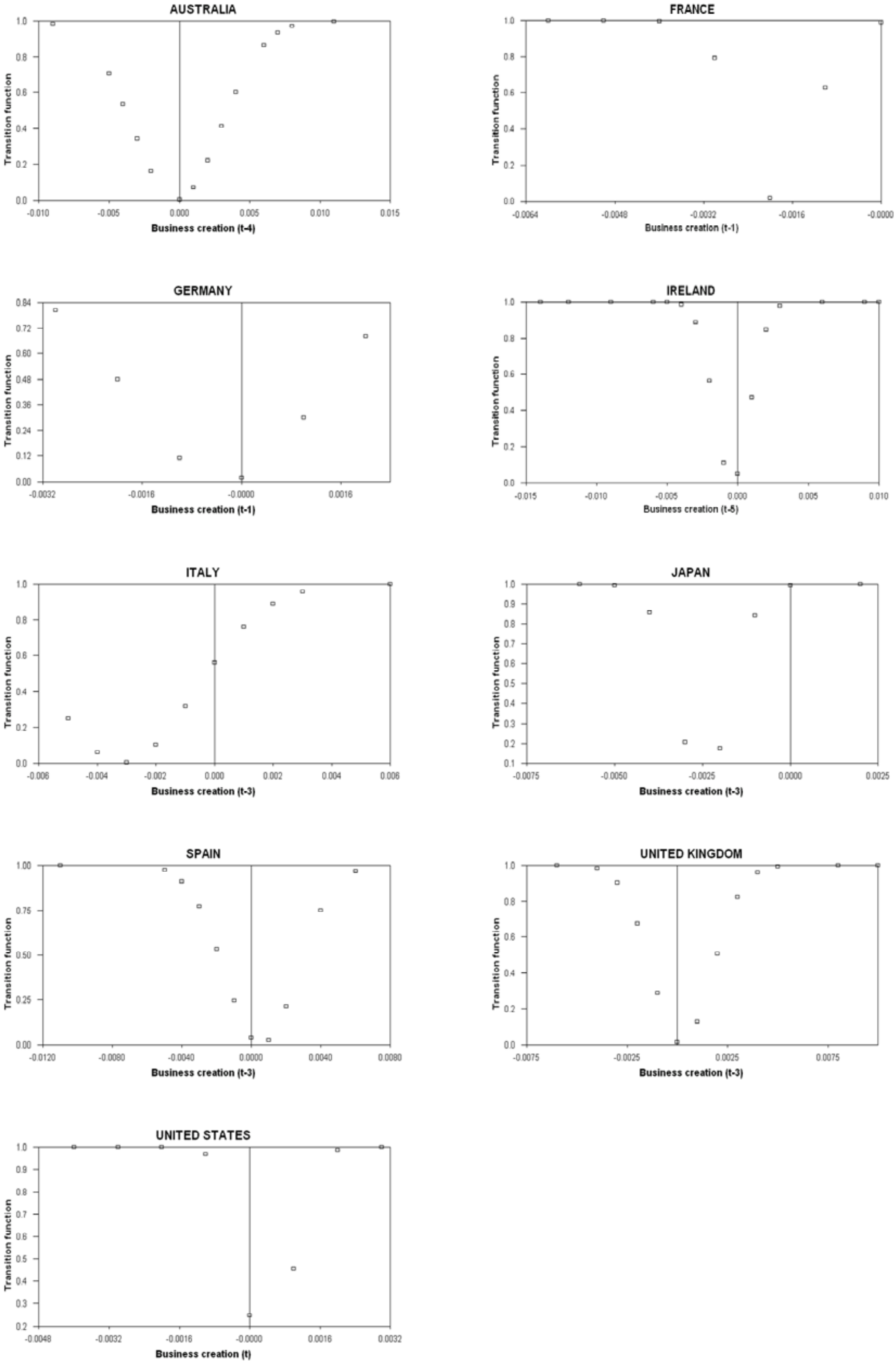
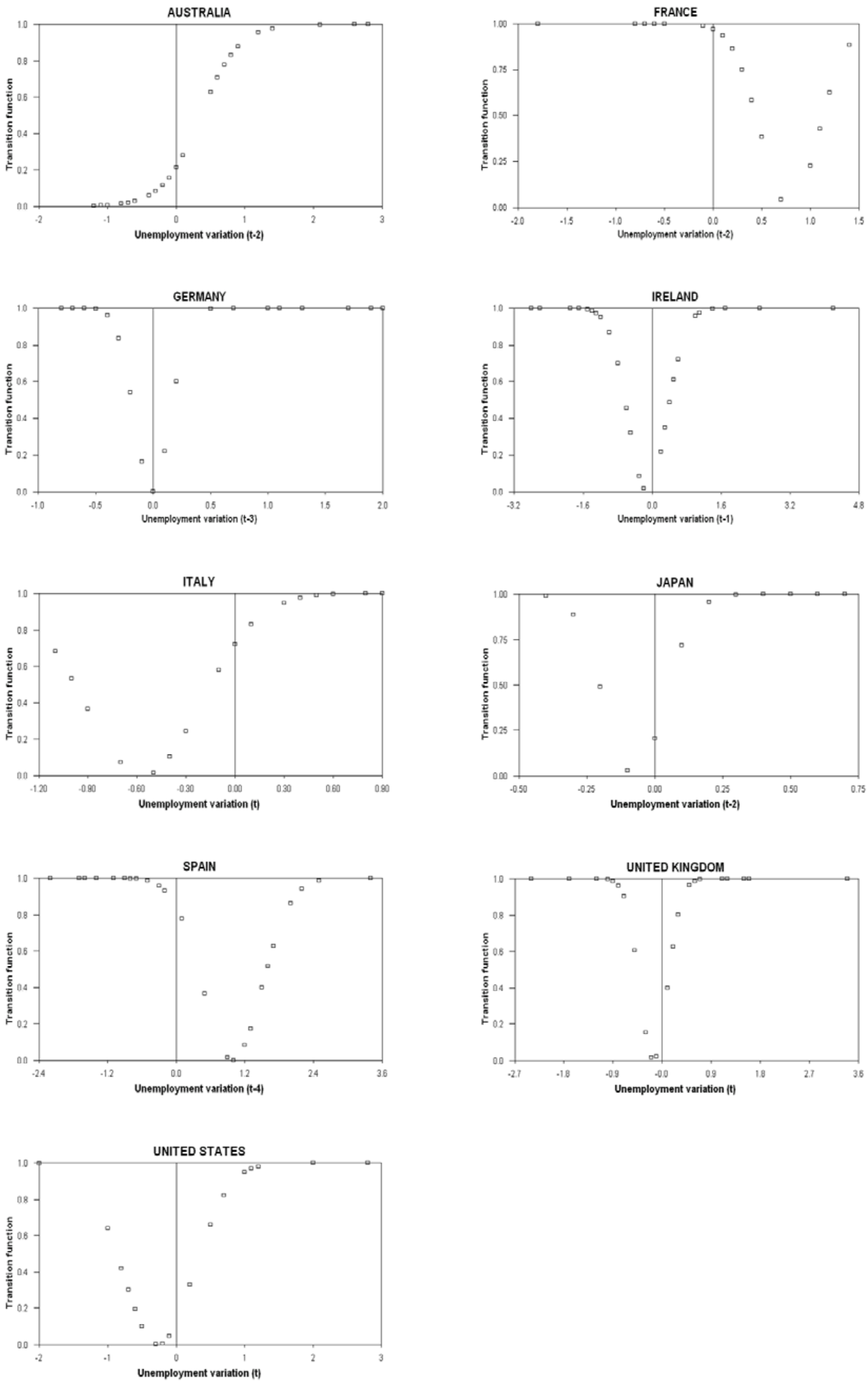


FIGURE 2

Estimated transition functions for business creation



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