Growth, Saving, Financial Markets and Markov Switching Regimes

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Abstract: We report evidence that the relation between the financial sector share, private savings and growth in the United States 1948–1996 is characterized by several regime shifts. The finding is based on vector autoregressions on quarterly data that allow for Markov switching regimes. The evidence may be interpreted as support for a hypothesis that the relation between financial development and growth evolves in a stepwise fashion. Theoretical models where financial market extensions entail fixed costs imply such stepwise patterns. The estimated variable relations are roughly consistent with the patterns to be expected from such models, although our data do not admit definite conclusions. The timing of the shifts coincide with changes in regulation and in the financial market structure.

Keywords: Financial markets extensions, growth, Markov switching, saving, vector autoregression.

JEL Classification Numbers: C32, E44, O16, O51.

1. Introduction

There are theoretical reasons why extensions of financial markets may be described as a regime switching process. Such a process can, for instance, be characterized by a transition regime, when large extensions occur, and an intermediate regime, when only minor extensions take place. Examples of what we mean by large financial markets extensions include the introduction of new instruments (such as options and mutual funds), new transactions technologies (such as computerized trading and automatic teller machines), and major changes in legislation (such as allowing banks to operate across state lines).

One reason why financial markets extensions take place discretely is that they involve inherent fixed costs; see e.g. Saint-Paul (1992) and Lindh (1994). Another reason is that indivisibilities in the production technology may require a threshold level of development in order to be insurable by financial diversification; see Acemoglu and Zilibotti (1997). If such factors are important we expect that sudden rises in the financial cost share are linked to changes in its relation to output growth and saving.

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It is an empirical issue whether regime shifts can actually be detected in the data and what the differences in the relations between these variables may be. To these ends, we analyze a Markov switching vector autoregression (MS-VAR) using quarterly data (1948–96) on changes in the financial sector share (as a proxy for costs) of U. S. corporate GDP, the growth rate of nonfinancial corporate GDP, and changes in the gross private saving rate. Such a model is well suited for our purposes since we do not wish to impose a priori restrictions on when regime shifts have occurred.[1] Neusser and Kugler (1998) is a recent time series study that uses that financial sector share as a measure of financial development.[2]

Our approach differs from the general literature on financial development by focusing on discrete and recurring shifts rather than on long run relations between growth and financial development. According to this literature financial development can influence growth in three ways: by raising the proportion of saving actually invested, by raising the social marginal productivity (as in e.g. Greenwood and Jovanovic, 1990, and Bencivenga and Smith, 1991), or by influencing the private saving rate (see e.g. Devereux and Smith, 1994, and Obstfeld, 1994). Levine (1997) provides a comprehensive survey of this literature.

For the MS-VAR model we find evidence of several regime switches and the estimated relations are broadly consistent with a set of stylized predictions. Moreover, the shifts seem to coincide in time with major changes in legislation and financial market structure, i.e. with large financial market extensions, thus adding credibility to the hypothesis that the shifts are not statistical artifacts, but indeed reflect real economic regime changes.

As expected the variables are considerably more volatile during the transition than during the intermediate regime and the average change in the saving rate is higher during the former periods. We also find that all three variables seem to contain unique information for predicting the regimes and that the financial sector share and the growth rate help predict the next period change in the saving rate.

The next section discusses in some detail the different patterns that could theoretically be expected in the relation between saving, growth and the financial sector share. Section 3 contains the empirical analysis. In Section 4 we attempt to relate the estimated regime process to the financial market evolution in the U. S. Finally, Section 5 offers our conclusions.

2. Dynamics of Financial Costs, Savings, and Growth

In this section we discuss the short run dynamics that would arise from financial regime shifts. This is an aid in the interpretation of the statistical model we use below to explore

[1] MS-(V)AR models have previously been used to examine phenomena such as business cycles (see e.g. Hamilton, 1989, and Diebold and Rudebusch, 1996), the term structure of interest rates (see Hamilton, 1988, and Sola and Driffill, 1994), and mean reversion in asset prices (Cecchetti, Lam, and Mark, 1990).

[2] In contrast to our study, Neusser and Kugler (1998) focus on the long run relation between financial development and growth.

the nexus of financial costs, growth, and saving. In the literature we have found no strong empirical evidence for any specific model explaining the connection between financial development and growth. The discussion below is therefore heuristic and does not rely on a formal model. However, we do rely rather heavily on general features that characterize many recently studied theoretical models.

As a point of departure we consider it a stylized fact that financial development has a long run positive relation to economic growth. In the recent surge of cross country regressions of growth on just about every conceivable variable, the positive correlation of financial development with growth is one of the few findings that seems reasonably robust to the inclusion of alternative sets of control variables.[3] Causality is, however, still a matter of debate.[4] Studying causality without due consideration of regime shifts is one possible source of confounded conclusions.

2.1. *Theoretical Background*

The main possibility we wish to explore is that financial development proceeds by a sequence of extensions that are separated in time. Specifically, we look for shorter transition regimes as financial markets are extended and longer intermediate regimes as the new market configurations are consolidated. Especially relevant in the previous theoretical literature are Saint-Paul (1992) and Acemoglu and Zilibotti (1997). These articles formalize a one time shift from a stage of underdeveloped financial markets to a stage with, more or less, complete financial markets. Diversification in the absence of financial insurance is achieved by using less risky but on average less productive technology. Saint-Paul's growth results hinge on fixed information costs in financial markets and a capital externality generating growth. Combined with an assumption of low risk preferences this ensures a positive effect on both savings and growth from financial development. Acemoglu and Zilibotti, in contrast, assume that there are indivisibilities in the technology itself and pecuniary externalities due to the absence of financial insurance. This setup does not rely on a positive savings effect to generate the positive growth effect.

Generalizing Saint-Paul's basic model, Lindh (1994) points out that there may well be a sequence of less than complete extensions of the financial markets. Allowing for precautionary saving, growth enhancing effects can be counteracted by saving declines. Empirical

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[3] See Levine and Renelt (1992) generally about fragility analysis and Levine and Zervos (1993) on robustness of financial development measures.

[4] Jung (1986) as Demetriades and Hussein (1996) find causality to be mainly bidirectional. King and Levine (1993a, 1993b) conclude that there is a long run causality from financial markets to growth. However, Arestis and Demetriades (1997) argue that the cross section evidence presented in the King and Levine papers is insufficient for causality analysis. Neusser and Kugler (1998) find long run causality in time series from the financial sector to manufacturing TFP. Lindh and Lindström (1997) report evidence that shifts in the financial sector share are associated with changing relations to growth and saving.

estimates of the parameters of the intertemporal elasticity of substitution suggest strong precautionary savings behavior. This, in turn, implies negative effects on saving when financial markets pool production risks and increases expected future utility from consumption.

In the empirical section we study the short run relations between the financial sector share (as a proxy for costs), φ, the growth rate g, and the rate of saving β. We find that the joint evolution of these variables in U. S. times series data is characterized by regime switches. In order to interpret these results it is useful to first state what dynamic patterns we would theoretically expect to observe in the data.

2.2. *Stylized Predictions*

Our study is exploratory and we do not formally test any specific model. Nevertheless, in order to have some theoretical benchmark for expected results, we make two specific assumptions:

1. Financial market extensions entail a cost that is fixed in relation to the production level.
2. In the long run growth is increased by financial development, but this effect is mediated through comparatively slow dynamics.

Combining these assumptions with general results from models in the literature we arrive at the expected relations that are summarized in Table 1. Our arguments for these expectations are briefly indicated below.

The Financial Sector Share

This measures transaction cost per unit of output. Output growth would thus tend to decrease the financial sector share. A higher saving rate, on the other hand, should increase the volume of transactions and thus the financial sector share. These conclusions could be modified by scale and scope economies in transactions, changes in transaction technology and so forth, but a fair guess is that φ increases with β and decreases with g in the *intermediate regime.* In the *transition regime* the cost hike due to added fixed costs should dominate and make predictions ambiguous.

The Saving Rate

Theoretically growth and the financial sector share have ambiguous effects on the saving rate. In both cases increases will raise expected utility of future consumption. With a high (low) intertemporal elasticity of substitution this increases (decreases) current savings. Since the ambiguities derive from offsetting income and substitution effects, savings should at least be affected in the same way by both variables in the *intermediate regime.* In the *transition regime* financial costs rise rapidly, so the direct effect on the saving rate is an unambiguous decrease. Moreover, high preceding growth rates of output given increased transaction costs may well be associated with lower saving rates.

The Growth Rate

In the long run saving rates as well as more extended financial markets should have a positive effect. However, an increasing cost share for financial transactions should hamper growth in the short run as would short run demand effects from increased savings. In the *intermediate regime* we thus expect a positive effect from the financial sector share. But this positive effect will not show up in the *transition regime*. An increasing saving rate would be expected to increase long run growth either transitorily or permanently but might have adverse effects on demand in the short run. Unlike the transition effect from rising financial costs, this demand effect from saving may show up also in the intermediate regime. At a quarterly frequency the demand effect could dominate.

In spite of several qualifications — indicated by question marks in Table 1 — the above arguments yield some guidance about the expected patterns for a VAR. The effect on savings of financial extensions and faster growth is expected to reveal whether precautionary saving is dominant or not in the intermediate regime. Transition periods should be rather short compared to intermediate regimes and should tend to be triggered by high preceding rates of growth.

3. The Empirical Analysis

In this section we examine empirical evidence for the intertemporal relationships between the extensions of financial markets, saving, and growth. In order to shed light on the issue discussed in the introduction we will let a vector autoregressive model (VAR) specialize into a Markov Switching vector autoregressive model (MS-VAR), and hence allow for different regimes to characterize the evolution of financial markets, saving, and growth.[5]

If it turns out that a two regime VAR seems fit to describe the data, we expect one relatively frequent regime and one considerably less frequent regime. There is one serious implication of this. Due to the limited amount of data available, the curse of dimensionality will effectively restrict the number of parameters in the model. As a consequence we will in the following consider models with one lag, i.e. compare a VAR(1) with an MS-VAR(1), although results for a VAR(4) are also presented for comparison. Furthermore, and for the same reason, the precision of the estimates for the less frequent regime will be low and hamper interpretability of that regime.

[5] As can be seen from (1) below, it is more appropriate to label a VAR as a special case of an MS-VAR, i.e. the case of a single regime model. However, the above formulation can be justified considering the long tradition of econometric VAR models in contrast to the recently introduced MS-VAR model. An example of the latter is Blix (1998) examining Swedish inflation in a trivariate, two regime model.

3.1. *U. S. Quarterly Data*

Data are available on a quarterly frequency from 1946 to 1996 in NIPA (National Income and Product Accounts, U. S. Department of Commerce, 1992, 1997). However, the latest revision we had available only extends back to 1959 (taken from EconData's April 1997 update). Data from he period 1946-1958 are taken from U. S. Department of Commerce (1992).

We took the most reliable indicator of financial costs to be the gross domestic product attributed to financial corporate business.[6] It is not obvious how the relative cost should be measured. In order to avoid problems of interpretation and to enhance comparability we have used the financial sector share measured as financial GDP divided by corporate business GDP (Table 1.16 row 18 divided by row 1) in current values. This avoids the tricky issue of how government production should be treated in this context as well as ameliorating the problem of linking data between the revision and earlier series. The changes in definition as compared with earlier data mainly concern the government sector.

The saving share has for similar reasons been measured as gross private saving divided by the sum of private consumption and private domestic investment (Table 5.1 row 2 divided by Table 1.1 row 2 plus row 6). While the earlier NIPA convention essentially only added the budget surplus to gross private savings to arrive at gross savings the current convention adds actual gross government saving which makes up the bulk of the difference between the GDP measures. This raises the gross saving share quite considerably. Our measure is designed to avoid this problem. Similarly for comparability the growth rate has been computed as the growth rate of real nonfinancial corporate business GDP ($g_t = \log(y_t/y_{t-1})$ where y is taken from Table 1.16 row 36).

From 1959:4 and onwards real values are in terms of chained 1992 dollars, while prior to this date real values are in fixed 1987 dollars. The reason that the first three quarters in 1959 of the growth series are computed from U. S. Department of Commerce (1992) is that the first two quarters are missing in the 1997 revision. Furthermore the growth series starts only in 1948 since real value estimates are lacking for the first two years.

3.2. *The Statistical Model*

In order to make data suitable for the proposed analysis we have made the following transformations: the financial sector share and the national saving rate are in first differences, and hence stationary.[7] Moreover, by multiplying these two series by 400 and the growth

[6] The finance and insurance sector includes a number of real estate and business services that are not strictly financial. To sort out this we would need considerably more detailed industry divisions than are published in NIPA and most likely we would run into trouble with numerous changes in definitions over such a long period.

[7] Karlsen (1990, Chapter 5) gives a sufficient condition for second order stationarity which applies to MS-VAR models; see also Holst, Lindgren, Holst, and Thuvesholmen (1994). As long as the autoregressive coefficients depend on the regime process, the stationarity condition for linear VAR models is not valid and, hence, the

rate by 100 we avoid numerical convergence problems in the estimations, and also get comparable measurement units.

Let x_t be a trivariate time series with components $x_t = (\Delta\varphi_t,\ \Delta\beta_t,\ g_t)$, where $\Delta\varphi_t$ is the annual change in the financial sector share of GDP, $\Delta\beta_t$ is the annual change in the private saving rate, and g_t the annual growth rate of real nonfinancial corporate business GDP. The vector x_t is assumed to be generated according to the following MS-VAR(p) model:

$$x_t = \mu_{s_t} + \sum_{k=1}^{p} A_{s_t}^{(k)} x_{t-k} + \varepsilon_t, \qquad t = 1, 2, \ldots, T, \tag{1}$$

where p is finite and typically small, $\varepsilon_t | s_t \sim N(0, \Omega_{s_t})$ with Ω_{s_t} being positive definite, and the initial values, $x_0, \ldots, x_{1-p}$, are taken as fixed.

The unobserved regime or state variable s_t is assumed to follow a q-state Markov process with transition probabilities $\Pr[s_t = j | s_{t-1} = i] = p_{ij}$, for all t and $i, j = 1, 2, \ldots, q$, and $\sum_{j=1}^{q} p_{ij} = 1$ is satisfied for all i. In addition, we assume that the Markov process is irreducible (no absorbing states) and ergodic.

For this particular application the maintained hypothesis is that $q = 2$, i.e. two states or regimes are sufficient for a fair description of the x_t process. We will, however, compare the two regime model with a traditional single regime VAR, i.e. the case of $q = 1$.

The random vector μ_{s_t} and the random matrices $A_{s_t}^{(k)}$ and Ω_{s_t} depend only on the state taken on by s_t. If $s_t = 1$, then $\mu_{s_t} = \mu_1$, $A_{s_t}^{(k)} = A_1^{(k)}$ and $\Omega_{s_t} = \Omega_1$. Maximum Likelihood (ML) estimates for the MS-VAR(1) model are obtained via the EM algorithm; for more details the reader is referred to Hamilton (1990, 1994). Standard errors for the point estimates are based on conditional scores, as in Hamilton (1996). The VAR(1) and the VAR(4) models are estimated with (Gaussian) ML.

Due to the presence of unidentified nuisance parameters under the null (the transition probabilities p_{ij} and the parameters of, say, the second regime) it is, as of yet, not clear how to test the single regime model against the two regime model.[8] However, it is still possible to empirically discriminate between the single regime VAR models and the MS-VAR(1) by examining their performances in terms of specification tests, e.g. test for serial correlation and autoregressive conditional heteroskedasticity.

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existing unit root tests may not be meaningful. Moreover, there is not any theoretical guidance on how to relate the idea of cointegration to MS-VAR models under this circumstance. Since the growth rate looks stationary (see Figure 3), while the log of the financial sector share seems to be trending (Figure 1), the saving rate appears highly persistent (Figure 2), and hence that it is unlikely that the latter two series are cointegrated, we decided to apply first differences to the two possibly nonstationary time series. The first differences of these series are depicted in Figures 4 and 5, respectively. When we calculate the modulus of the largest eigenvalue, as defined by Karlsen, for the estimated first differenced MS-VAR(1) we find that it is roughly 0.43 and, hence, well inside the stationary region.

[8] Some procedures have been suggested in the literature, for instance Hansen (1992).

3.3. *Specification Results*

Table 2 presents some stylized facts about the behavior of the change in the financial sector share of GDP, the change in the saving rate, and the growth rate. Over the sample period we find that the change of the financial sector share of GDP each quarter is 0.1 percent with a standard deviation of about 0.8 percent. The average change per quarter in the saving rate is approximately zero, but this series is considerably more volatile than the other two; it has an estimated standard deviation of roughly 4 percent. The average growth rate is much higher, about 1.75 percent, with a standard deviation of about 2.8 percent. Moreover, the three variables do not seem to be contemporaneously correlated as indicated by the small covariances.

Having estimated the MS-VAR(1) model, we may calculate the corresponding state conditional moments; see Warne (1996a) for details on the relationship between the state contingent moments and the parameters of the MS-VAR model. First, we find that about 168 observations belong to Regime 1 and the remaining 26 to Regime 2. The probability to remain in Regime 1 is estimated to be 95 percent and the corresponding estimate for Regime 2 is 66 percent. The point estimates of the Markov transition probabilities indicate that both regimes are persistent and that the second regime occurs less frequently than the first. An F-statistic version of the Wald test of the hypothesis that the Markov chain is not serially correlated, i.e. that the transition probabilities are equal to the long run or ergodic probabilities, is strongly rejected by the data when inference is based on the assumption of asymptotic normality.

Table 3 displays the conditional first two moments for x_t. The most apparent difference between the two states is the greater volatility recorded for the less frequently occurring second state; standard deviations are roughly 3 times larger in Regime 2. As for first moments, it can be seen that the mean of g_t is slightly larger in the stable first state, whereas the mean of $\Delta\beta_t$ is negative in the first state and in the second, volatile state, positive and considerably larger than the unconditional mean. Finally, the second state is associated with a decline in the financial sector share. The two states can be described as one stable and one volatile where saving increases and the financial sector share decreases.

Prior to an interpretation of the estimated state conditional parameters of model (1) it is useful to evaluate the data description properties of the MS-VAR(1) model. We will use a VAR(1) and a VAR(4) as reference models and examine how the three models conform to the assumptions of serially uncorrelated residuals and no autoregressive heteroskedasticity. Test results are summarized in Table 4.

According to the univariate specification tests the VAR(1) model is severely misspecified with respect to serial correlation, ARCH, and normality. This is not surprising when looking at the differenced data in Figures 3–5 which displays periods, or clusters, of high volatility. The null hypotheses for the MS-VAR(1) model can only be rejected in the case of ARCH in the financial sector share equation. Moreover, when testing the VAR(1) as a system, the multivariate tests suggest rejection of multivariate normality and serial correlation (p-values are .000 and .001 respectively). A multivariate ARCH test in the MS-VAR(1) model cannot be rejected, nor a multivariate test of serial correlation (p-values are .239 and .691, respectively).

Based on these tests our conclusion is therefore that the MS-VAR(1) provides an adequate description of the data, whereas the VAR(1) does not. In order to check that this result is not simply an effect of a larger set of parameters in the MS-VAR(1), or from serial correlation in the VAR(1), we undertook the same tests for a VAR(4). The results show that this larger model is still misspecified, and the periodic volatility outbursts are not accounted for even with four lags, while there is no evidence of serial correlation.

3.4. *The Theoretical Predictions Meet the Data*

The results in Table 5 indicate effects in the intermediate regime (Regime 1) that are in rather good agreement with the theoretically expected pattern in Table 1. The financial sector share is positively affected by previous savings and negatively by previous growth as expected. The saving share is negatively (although insignificantly) affected by both the other variables. Although the sign could not be a priori determined the negative effect is in fact the one expected from empirical work on the elasticity of intertemporal substitution indicating that income effects dominate the saving response. Growth is related negatively to previous changes in the financial sector share and positively to the saving rate.

The estimated coefficients in the transition regime (Regime 2) are also close to the expected. However, being very imprecisely estimated, due to the few “observations” of that regime, we cannot attach much importance to the point estimates. A glance at Figure 1 indicates that the estimated transition regimes are catching downturns *after* a financial sector expansion rather than the expansions themselves.

One implication for the MS-VAR of the hypothesized pattern of effects in Table 1 is that the financial sector share should Granger cause the growth rate in mean-variance. Technically, this means that for some time periods

$$E[u_{g,t}^2 | \{\Delta\varphi_\tau, \Delta\beta_\tau, g_\tau\}_{\tau=1-p}^{t-1}] \neq E[\tilde{u}_{g,t}^2 | \{\Delta\beta_\tau, g_\tau\}_{\tau=1-p}^{t-1}],$$

where $u_{g,t} = g_t - E[g_t | \{\Delta\varphi_\tau, \Delta\beta_\tau, g_\tau\}_{\tau=1-p}^{t-1}]$, and $\tilde{u}_{g,t} = g_t - E[g_t | \{\Delta\beta_\tau, g_\tau\}_{\tau=1-p}^{t-1}]$; Warne (1996b) presents the set of necessary and sufficient conditions for Granger noncausality in mean (the standard Granger noncausality hypothesis), mean-variance, and distribution (conditional independence). Similarly, the pattern of effects in Table 1 implies that the financial sector share should be Granger causal for the saving rate in mean-variance.[9]

For the MS-VAR model, there are two channels through which, say, $\Delta\varphi$ can be useful for predicting the g. First, it can help to predict the regime (an "indirect" prediction channel). Second, conditional on the regime, it can help improving the one step ahead forecast of the growth rate. Since there are two channels through which the financial sector share can be informative about the next period value (and the uncertainty of the prediction error), there is not a unique set of parameter restrictions for testing the noncausality hypothesis. However, there is a finite number of cases and if one of these cases is true, then $\Delta\varphi$ is Granger noncausal in mean-variance for the variable we are interested in. Given an MS-VAR model with 2 regimes and 3 observable variables, the total number of such cases is four.[10]

In the case of, say, the hypothesis $\Delta\varphi \not\Rightarrow g$, a common feature of the four sufficient conditions is that, conditional on the regime and the past values of $\Delta\beta$ and g, $\Delta\varphi$ does not help to predict the next period value of g. Letting a_{ij,s_t} denote the (i,j):th element of $A_{s_t}^{(1)}$, this means that $a_{31,s_t} = 0$ for both regimes. These restrictions represent the second prediction channel that was mentioned in the previous paragraph.

In Table 6 we report F-statistics and p-values from testing the hypothesis that $a_{ij,s_t} = 0$ for both values of s_t and with $i,j = 1,2,3$. The evidence here agrees with the results in Table 5 and, in particular, we cannot reject the hypotheses that the coefficients on the lagged financial sector share are zero for both the saving rate and the growth rate equations.

Next, in Table 7 we report F-statistics of Granger noncausality in the six different directions that are possible in our model. For a given pair, e.g. the financial sector share and the saving rate ($\Delta\varphi \not\Rightarrow \Delta\beta$), the noncausality hypothesis implies that at least one of the four sets of restrictions, (C1.1), (C1.2), (C2), and (C3), must be satisfied; the specific parameter restrictions are given in the Table.

For the case when we wish to test the hypothesis that $\Delta\varphi$ is Granger noncausal in mean-variance for $\Delta\beta$, the restrictions (C1.1), (C1.2), and (C2) imply that $\Delta\varphi$ is conditionally non-informative about the regime, while (C3) implies that $\Delta\beta$ does not directly depend on the

[9] The predictions in Table 1 do not, however, imply that the financial sector share should be Granger causal for the growth rate or the saving rate in *mean*, i.e. the variances of $u_{g,t}$ and of $\tilde{u}_{g,t}$ can be equal. The reason is that if the Markov process is serially uncorrelated, then Granger noncausality in mean implies that the expected value of the random coefficient on $\Delta\varphi_{t-1}$ in the saving rate and in the growth rate equation, respectively, are zero. As long as the two possible values for each random coefficient have opposite signs, the weighted (by the ergodic probabilities for the Markov process) sum of the two values can be zero for each case. This is consistent with the hypothesized relationships in Table 1. Noncausality in mean-variance, however, requires that each possible value for these random coefficients is zero, and is therefore not consistent with the pattern of effects in Table 1.

[10] Under the assumption of conditional normality for ε_t in equation (1) and that the matrix with Markov transition probabilities has either full rank or rank equal to one (which is always satisfied when there are two regimes), Warne (1996b) shows that Granger noncausality in mean-variance is equivalent to Granger noncausality in distribution.

regime (other than via g or the residual covariances). Moreover, the (C1.1) and (C1.2) restrictions allow the Markov process to be serially correlated, while (C2) does not. Finally, (C1.1) and (C1.2) are different in the sense that (C1.1) means that *only* $\Delta\varphi$ has to be conditionally informative about the Markov process, while (C1.2) implies that both $\Delta\varphi$ and g are conditionally informative about the regime process. The former case turns out to imply that $\Delta\varphi$ is Granger noncausal in mean-variance for g as well as for $\Delta\beta$, while the latter case happens to imply that both $\Delta\varphi$ and g are Granger noncausal in mean-variance for $\Delta\beta$.[11]

From Table 7 we find that the (C1.1), (C1.2), and (C2) restrictions are strongly rejected by the data for both the saving rate and for the growth rate case. This suggests that the financial sector share process contains unique information for predicting the regime process. Exactly how it matters depends on which restriction(s) is (are) not consistent with the data. However, at the 5 percent level of marginal significance, we can only reject the (C3) hypothesis in the case of the saving rate. In other words, the financial sector share seems to be Granger causal (in mean-variance) for the saving rate, but not for the growth rate. Moreover, the growth rate appears to be Granger causal for the saving rate.

Apart from Granger causality from $\Delta\varphi$ and from g to $\Delta\beta$, there is no evidence of such causal links. Interestingly enough, it is always the (C3) restrictions that cannot be rejected for these cases, while the other sets of restrictions are always rejected. This means that all three variables are useful for making inference about the regime process and that the evidence on causality is primarily found in the equation describing the saving rate. The volatility outbursts, evident in Figures 3–5, can be found in all three time series and, thus, explain the former result.

4. What Happened at the Transitions?

We estimate five transition regimes with duration greater than two quarters. The transition period 1992–1993 is closely followed by two further indications of regime shifts in the second halves of 1994 and 1995. The latter of these is not as pronounced as other switches. The two estimated instances of the transition regime in the beginning of the 1980s are probably linked. We therefore consider four transition periods; the first 1950–1951, the second around 1975, the third mainly in 1982, and a longer fourth period 1992–1994.

Do these transition periods have any connection to real events? To answer that question we survey some literature on the development of the U. S. financial system.

The interaction between financial developments and legislation is, of course, a case of mutual interdependence. Changes in the financial system necessitate changes in legislation, in turn precipitating new changes in the financial system. However, the causal connection is

[11] Notice that these two sets of restrictions are *not* nested.

by most observers seen as running from financial system pressures to legislation. Deregulation has to a large extent been motivated by practices that already had started to evolve within the bounds of the old rules.

Below we very briefly specify some events which are connected to switches in financial regime. What events are we looking for? Our maintained hypothesis is that the volatile transition regimes found in the empirical record signify comparatively rapid extensions of the financial markets that are associated with fixed costs. We also look for events in the years just before a transition period, since the data show that financial sector share expansions tend to precede the transition regimes; cf. Figure 1. Thus, the appearance of more comprehensive financial markets as well as new financial instruments qualify to the extent that they are associated with higher fixed costs.

4.1. *The Transition Periods*

A discussion of the post war U. S. financial history with a complete analysis of the chains of events around the transition periods and their causes is beyond the purpose of this article. Nevertheless, we find it useful as an informal check of our results to give a short account of important financial events that potentially are connected to rapid market extensions in the transition periods. Of course, a concentration of important financial events around the transition periods does not verify our hypothesis. However, if no such events could be found it would be a strong indication that the hypothesis is false. Below we give a cursory review of events that did take place around the estimated transitions.

First Period 1950:1–51:3

Financial restrictions from the war were abandoned towards the end of the 1940s. Consumer credit controls were abolished in June 1949 and interest ceilings on deposits were successively raised through 1948. In June 1950 the Korea War began, leading to a short speculative boom.

The most important event was that credit outstanding from the Federal Reserve increased very fast in 1949–1950. In part this was a reflection of the record mortgage volumes that were accompanied by a liberalization of government mortgage programs in 1950. In 1950 federal insurance of savings and loans associations was raised to the same level as that for commercial banks, and savings bank statutes were amended to allow out-of-state federally underwritten mortgages (Klaman, 1961). Thus, extensive restructuring of the mortgage markets must have taken place within the estimated transition period.

Second Period 1975:1–75:4

This transition period was preceded by a great amount of turbulence in international financial markets and regulation. The end of the Vietnam war and the first oil crisis were important events which contributed to a high pressure for change in the financial system. Also the domestic financial system underwent substantial changes both in terms of organization and in terms of financial innovations and new markets.

Negotiated brokerage commissions were allowed in 1975 and the structure of investment banking rapidly changed. In 1973 the final breakdown of the Bretton-Woods system had made new services for international payments necessary. In 1974 automated brokerage services were made available to primary dealers in Treasury securities. Trade in interest rate futures were introduced in Chicago 1975, see Wilson (1993).

During the period 1971–73 the regulation of negotiable certificates of deposits was abolished. This lead to massive volume increases in the trading of these instruments up to 1975. 1972–73 NOW-accounts started to evolve, i.e. saving accounts with negotiable orders of withdrawal, in effect an interest bearing checking account. These accounts circumvented Regulation Q, under which regular demand deposits had a zero interest rate ceiling. This was only part of a general movement in the markets to find ways around the interest regulations. See Klebaner (1990) for more details.

Thus, 1975 was the culmination of a period of fundamental changes in the financial system that took place in several areas and was followed by a calmer development for a few years before the pressure for change started to mount again.

Third Period 1981:3–82:3

In 1982 Congress responded to market pressures and doubled the statutory limits on bankers acceptances to 200 percent of bank capital. Money market deposits were allowed in 1982. In 1981 International Banking Facilities were exempted from reserve requirements and from some state and local government taxation in order for U. S. banks to be competitive in international markets. A Supreme Court ruling in 1981 accelerated merger activities as regulators were forced to become more liberal. In 1982 the Garn-St Germain Act allowed thrifts to offer banking services previously reserved for commercial banks.

The period was also preceded by a number of deregulations. In December 1980 shelf registration of bond issues was allowed, i.e. anticipatory clearing of bond issues. In 1980 interest rate regulation started to phase out over the following six years. 1980–82 savings and loans associations were given more discretion in the range of services they could offer, for details see Meerschwam (1991) and Mullineux (1987).

These deregulations were also reflected in the financial markets. The market for so called junk bonds (lacking normal credit rating) started to increase rapidly in 1981. Options on a diverse array of futures contracts were introduced at several exchange markets in 1982. Automated teller machines made branching regulation even less efficient than before. Mortgage-backed securities and federally backed variable rate mortgages were allowed. Securitization of international debt as well as loan sales, interest swaps and other innovative financial activities expanded, see Klebaner (1990). There was a general tendency to dissolve the distinctions between local thrifts — mainly savings and loan associations — on one hand and commercial banks and investment banks on the other. Mullineux (1987) discusses this in detail.

This transition period was thus characterized by turbulent restructuring of the financial markets and a much more extensive deregulation than in the previous periods.

Fourth Period 1992:2–93:1 & 1994:2–3.

In 1991 the federal deposit insurance was reformed towards risk based insurance. World wide futures and options trading was introduced in 1992. In 1994 the Riegle-Neal Interstate Banking and Banking Efficiency Act finally imposed federal rules allowing bank holding companies and commercial banks to establish branch units across state lines. More details can be found in OECD (1992-1995).

The period was preceded by a rapid expansion of regional banking due to state deregulation at the end of the 1980s, see Hawawini and Swary (1990). In 1993 the junk bond market went through a revival. As a response to the problems of thrift institutions, mainly savings and loan associations in the 1980s, the previous regulatory authorities were dissolved in 1989 and replaced by the Office of Thrift Supervision which in the following years reduced the reliance on deposit funding that had caused much of the problems, see Stiroh (1997).

This transition period marks the beginning of a very rapid expansion of existing markets and trading instruments. Deregulation in and before this period is generally seen as long overdue responses to market developments that already had taken place.

4.2. *Summary of Evidence*

Every regime shift is associated with new developments on the financial markets and in the regulatory framework although the character of these developments vary. The transition regime is characterized by a higher volatility than the intermediate regime and (some of) the estimated transition periods may be connected to recessions. This could be interpreted to mean that we simply pick out recession phenomena and variations in volatility, due to other causes than financial development. However, the shifts are associated with upturns from recessions in economic activity but upturns from recessions are not always associated with regime shifts.

Exogenous events like the downfall of Bretton-Woods, the end of the Vietnam war and the oil crisis 1973 may certainly have caused some of the volatility in 1975, for example. Our point is not that the Markov transitions are causally related to financial market extensions.

Rather, whatever the ultimate causes are the transition patterns we see in the data seem to be associated with widespread changes and growth in the financial markets.

There are important financial events that are not associated with the transition periods. An obvious example is the stock market crash in 1987. Our survey of U. S. financial history does not allow us to conclude that there is a qualitative difference between the development in the transition regime as compared to the development in the intermediate regime. However, the accounts of the evidence we have found are at least not inconsistent with such a view. We cannot falsify our maintained hypothesis on the grounds that nothing much happened in the financial markets in and around the estimated transition periods.

5. Conclusions

The main conclusion from our work is that the MS-VAR model successfully describes the data since it can account for much of the apparent heteroskedasticity. This indicates that the possibility of regime switches should be taken into account when analyzing the time series relations between financial development and growth.

The autoregressive patterns in the intermediate regimes are largely consistent with theoretical expectations. These patterns indicate that the main effect of financial development is to decrease precautionary savings. The patterns in the transition regime — although not well determined — are widely conforming to the expected.

There is plenty of institutional evidence that the statistically determined transition periods are associated with new developments on the financial markets on several levels. Substantive changes in regulation as well as rapid developments in new financial instruments and markets are closely associated with the timing of the transition regimes.

Further research along these lines may shed new light on the old question of causality between financial development and growth. Our Granger causality analysis points in the direction that causal (predictive) effects can only be discovered from the financial sector share and from growth to the saving rate. This is consistent with the finding that all three variables are useful when attempting to make inferences about the regime process.

It should be emphasized that the noncausality hypothesis concerns only one quarter ahead predictions and that our results have little (if anything) to say about longer forecast horizons. Since the length of a time period in the theoretical discussion is unspecified (although it is not far fetched to take it to be longer than one quarter), the lack of Granger causality from the financial sector share to the growth rate should not be interpreted as strong evidence against the hypothesis of a causal link from financial development to growth. It suggests, however, that the dynamics of the link need to be better specified in order to settle the issue.

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TABLE 1: Hypothesized pattern of effects in different regimes.

	intermediate		
	φ_{t-1}	β_{t-1}	g_{t-1}
φ_t	?	+?	−?
β_t	+/−	?	+/−
g_t	+	+(−)?	?

	transition		
	φ_{t-1}	β_{t-1}	g_{t-1}
φ_t	?	?	?
β_t	−	?	−?
g_t	−	−	?

TABLE 2: Estimated state independent moments.

variable	mean	covariances		
$\Delta\varphi_t$	.103	.693	−.612	−.784
	(.092)	(.388)	(2.400)	(.756)
$\Delta\beta_t$	.020	−	15.910	.917
	(.282)		(10.869)	(2.340)
g_t	1.758	−	−	8.005
	(.491)			(2.326)

TABLE 3: Estimated state dependent moments for a 2-state MS-VAR(1) model.

Regime 1				
variable	mean	covariances		
$\Delta\varphi_t$	.145	.316	−.342	−.655
	(.068)	(.046)	(.156)	(.168)
$\Delta\beta_t$	−.058	–	7.527	.098
	(.242)		(.974)	(.602)
g_t	1.805	–	–	5.960
	(.287)			(.768)
Regime 2				
variable	mean	covariances		
$\Delta\varphi_t$	−.165	3.007	−2.169	−1.695
	(.481)	(2.618)	(17.537)	(4.921)
$\Delta\beta_t$	.518	–	68.84	6.283
	(1.652)		(72.364)	(17.389)
g_t	1.457	–	–	20.88
	(3.005)			(15.086)
The Markov Process				
	$\hat{p}_{11}$ =.947		$\hat{p}_{22}$ =.663	
	(.032)		(.157)	
	$\hat{\pi}_1$ =.864		$\hat{T}_1$ = 167.7	
	(.063)		(12.2)	
H_0:	$p_{11} + p_{22} = 1$		$F = 39.68$	
			[.00]	

TABLE 4: Univariate specification tests for a MS-VAR(1), a VAR(1), and a VAR(4) with respect to serially uncorrelated residuals, normality, and no autoregressive heteroskedasticity

	serial correlation		normality		ARCH	
VAR(1)	statistic[a]	p-value	statistic[b]	p-value	statistic[c]	p-value
$\Delta\varphi_t$	2.36	.042	105.17	.000	3.79	.006
$\Delta\beta_t$	2.93	.014	32.66	.000	16.69	.000
g_t	1.18	.321	20.64	.000	5.79	.000
VAR(4)	statistic[d]	p-value	statistic[b]	p-value	statistic[e]	p-value
$\Delta\varphi_t$	1.31	.263	100.39	.000	2.40	.052
$\Delta\beta_t$	1.38	.234	11.41	.003	13.78	.000
g_t	0.49	.783	25.44	.000	2.04	.092
MS-VAR(1)	statistic[f]	p-value			statistic[g]	p-value
$\Delta\varphi_t$	1.23	.298	–	–	2.98	.020
$\Delta\beta_t$	1.46	.216	–	–	1.29	.275
g_t	1.03	.396	–	–	2.26	.064

[a] is an F(5,185)-statistic for an LM test of serial residual correlation as reported by Pc-Fiml 9.0

[b] is a $\chi^2(2)$–statistic for normality based on excess skewness and kurtosis as reported by Pc-Fiml 9.0

[c] is an F(4,182)-statistic for an LM test of ARCH based on lagged squared residuals as in Pc-Fiml 9.0

[d] is an F(5,173)-statistic for an LM test of serial residual correlation as reported by Pc-Fiml 9.0

[e] is an F(4,170)-statistic for an LM test of ARCH based on lagged squared residuals as in Pc-Fiml 9.0

[f] is an F(4,178)-statistic for a test of serial residual correlation based on conditional scores

[g] is an F(4,178)-statistic for a test of ARCH based on conditional scores

TABLE 5: ML Estimates of μ_{s_t}, $A_{s_t}^{(1)}$, $s_t = 1, 2$, for the MS-VAR(1) model; estimated standard errors based on conditional scores within parentheses, and significant coefficients in bold.

equation	μ_1		$A_1^{(1)}$		μ_2		$A_2^{(1)}$	
$\Delta\varphi_t$	**0.148**	**0.236**	0.010	-0.018	-0.060	-0.612	0.012	-0.093
	(0.071)	(0.077)	(0.017)	(0.024)	(0.740)	(0.713)	(0.241)	(0.352)
$\Delta\beta_t$	0.117	-0.340	-0.004	-0.073	2.161	0.416	-0.676	**-0.888**
	(0.338)	(0.384)	(0.057)	(0.119)	(2.572)	(2.225)	(0.444)	(0.408)
g_t	**1.332**	-0.062	0.010	**0.269**	0.866	-0.525	-0.173	0.391
	(0.295)	(0.361)	(0.069)	(0.083)	(1.720)	(3.737)	(0.275)	(0.818)

TABLE 6: F-tests of the hypothesis that $a_{ij,s_t}^{(1)} = 0$ for both regimes with p-values within brackets.

variable	$\Delta\varphi_{t-1}$	$\Delta\beta_{t-1}$	g_{t-1}
equation			
$\Delta\varphi_t$	4.597	.189	.316
	[.011]	[.828]	[.730]
$\Delta\beta_t$	.370	1.095	2.452
	[.691]	[.337]	[.089]
g_t	.026	.187	5.261
	[.975]	[.830]	[.006]

The reference distribution is $F(2, T-12)$ and the F-statistic is computed as $F = ((T-12)/(2T))W$, where W is the Wald statistic.

TABLE 7: F-tests of various Granger noncausality in mean-variance hypotheses with p-values in brackets.

H_0	r	$\Delta\varphi \nRightarrow \Delta\beta$ F	$\Delta\varphi \nRightarrow g$ F	$\Delta\beta \nRightarrow \Delta\varphi$ F	$\Delta\beta \nRightarrow g$ F	$g \nRightarrow \Delta\varphi$ F	$g \nRightarrow \Delta\beta$ F
(C1.1)	13	3.383	3.383	2.564	2.564	3.085	3.085
		[.000]	[.000]	[.003]	[.003]	[.000]	[.000]
(C1.2)	19	2.568	3.293	2.969	3.293	2.969	2.568
		[.001]	[.000]	[.000]	[.000]	[.000]	[.001]
(C2)	3	5.375	4.583	4.304	3.956	3.903	5.535
		[.001]	[.004]	[.006]	[.009]	[.010]	[.001]
(C3)	6	2.602	.604	1.131	.603	1.200	2.443
		[.019]	[.726]	[.346]	[.728]	[.308]	[.027]

The $F(r, T-s)$-approximated F-statistic is computed from $F = ((T-s)/(Tr))W$, where W is the Wald statistic, r is the number of restrictions, and s is the closest integer to the average number of free parameters per equation under H_0, i.e. $s = \text{int}[(38-r)/3]$.

For (C1.1) the reference distribution is $F(13, T-8)$. The set of restrictions is: $\mu_{i,1} = \mu_{i,2}$, $a_{i1,1} = a_{i1,2}$, $a_{i2,1} = a_{i2,2}$, $a_{i3,1} = a_{i3,2}$, $a_{ji,1} = 0$, $a_{ji,2} = 0$, $a_{ki,1} = 0$, $a_{ki,2} = 0$, $\omega_{ii,1} = \omega_{ii,2}$, $\omega_{ij,1} = 0$, $\omega_{ij,2} = 0$, $\omega_{ik,1} = 0$, $\omega_{ik,2} = 0$ for the hypothesis $x_i \nRightarrow x_j$, where $k \notin \{i, j\}$ while $x_1 = \Delta\varphi$, $x_2 = \Delta\beta$, and $x_3 = g$.

For (C1.2) the reference distribution is $F(19, T-6)$. The set of restrictions is: $\mu_{i,1} = \mu_{i,2}$, $\mu_{k,1} = \mu_{k,2}$, $a_{i1,1} = a_{i1,2}$, $a_{i2,1} = a_{i2,2}$, $a_{i3,1} = a_{i3,2}$, $a_{k1,1} = a_{k1,2}$, $a_{k2,1} = a_{k2,2}$, $a_{k3,1} = a_{k3,2}$, $a_{ji,1} = 0$, $a_{ji,2} = 0$, $a_{jk,1} = 0$, $a_{jk,2} = 0$, $\omega_{ii,1} = \omega_{ii,2}$, $\omega_{ik,1} = \omega_{ik,2}$, $\omega_{kk,1} = \omega_{kk,2}$, $\omega_{ij,1} = 0$, $\omega_{ij,2} = 0$, $\omega_{kj,1} = 0$, $\omega_{kj,2} = 0$ for the hypothesis $x_i \nRightarrow x_j$, where $k \notin \{i, j\}$.

For (C2) the reference distribution is $F(3, T-12)$. The set of restrictions is: $p_{11} = p_{21}$, $a_{ji,1} = 0$, $a_{ji,2} = 0$ for the hypothesis $x_i \nRightarrow x_j$.

For (C3) the reference distribution is $F(6, T-11)$. The set of restrictions is: $\mu_{j,1} = \mu_{j,2}$, $a_{ji,1} = 0$, $a_{ji,2} = 0$, $a_{jk,1} = a_{jk,2}$, $a_{jj,1} = a_{jj,2}$, $\omega_{jj,1} = \omega_{jj,2}$ for the hypothesis $x_i \nRightarrow x_j$, where $k \notin \{i, j\}$.

FIGURE 1: Financial sector share of corporate GDP with the estimated transition regime periods, $\Pr[s_t = 2|\mathcal{X}_T; \hat{\theta}] > 0.5$, in the shaded areas.

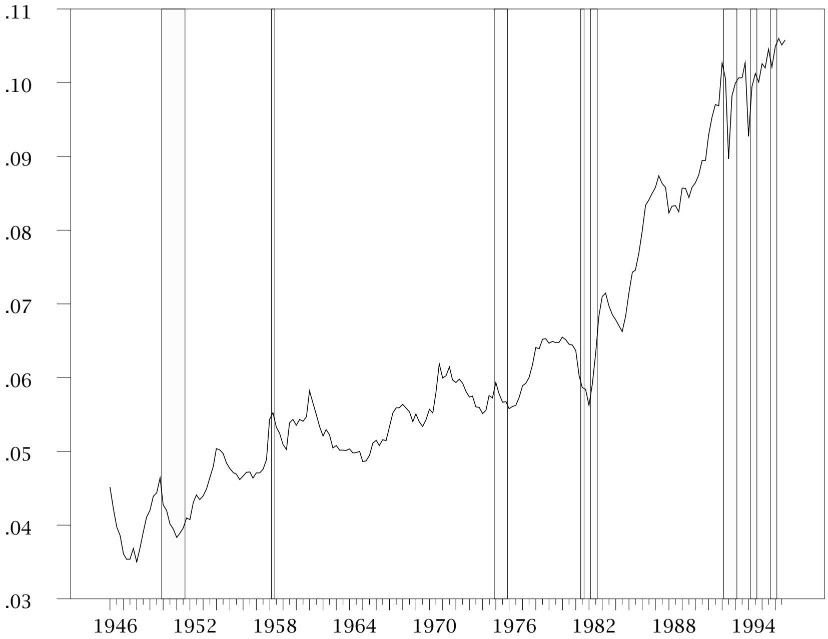


FIGURE 2: Gross private saving rate with the estimated transition regime periods, $\Pr[s_t = 2|\mathcal{X}_T; \hat{\theta}] > 0.5$, in the shaded areas.

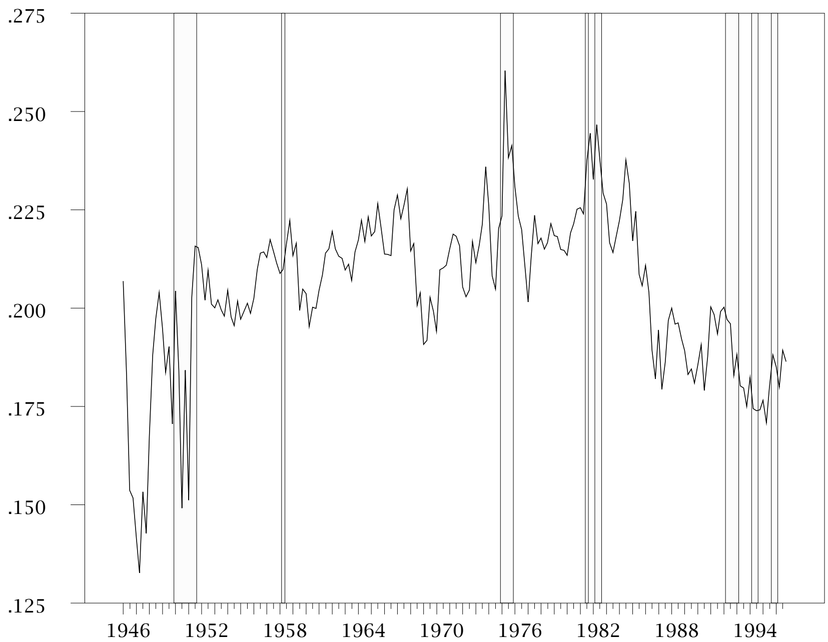


FIGURE 3: Growth rate of nonfinancial corporate GDP with the estimated transition regime periods, $\Pr[s_t = 2|\mathcal{X}_T; \hat{\theta}] > 0.5$, in the shaded areas.

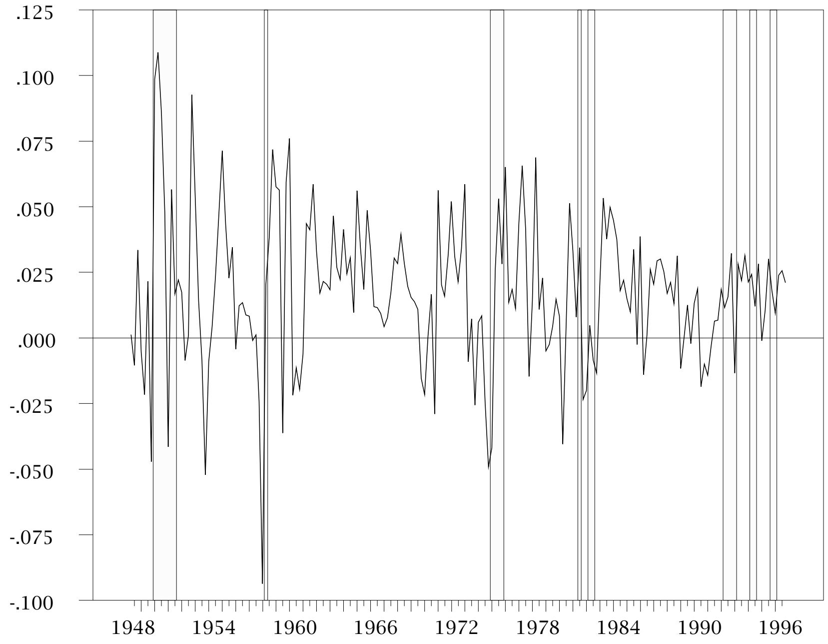


FIGURE 4: First differences of financial sector share of corporate GDP with the estimated transition regime periods, $\Pr[s_t = 2|\mathcal{X}_T; \hat{\theta}] > 0.5$, in the shaded areas.

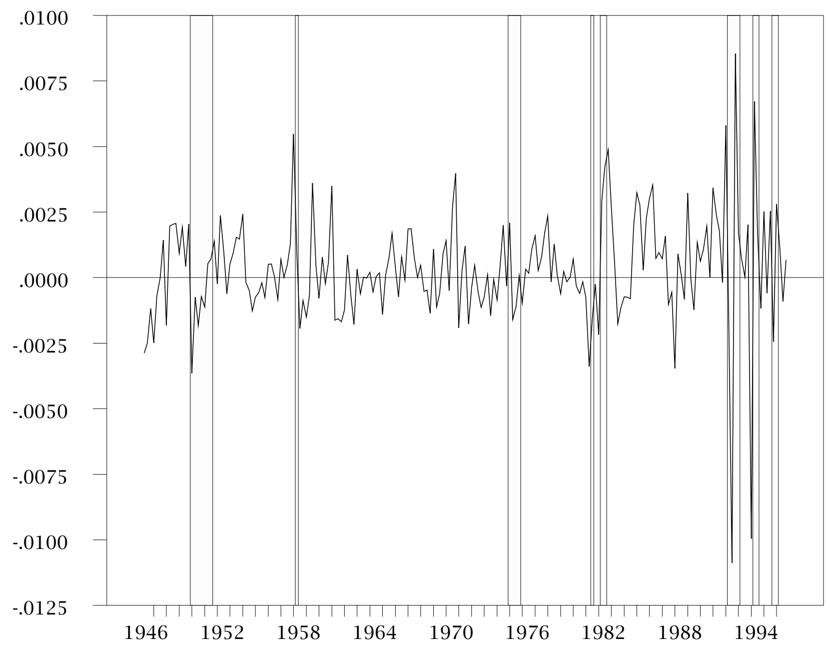


FIGURE 5: First differences of the gross private saving rate with the estimated transition regime periods, $\Pr[s_t = 2|\mathcal{X}_T;\hat{\theta}] > 0.5$, in the shaded areas.

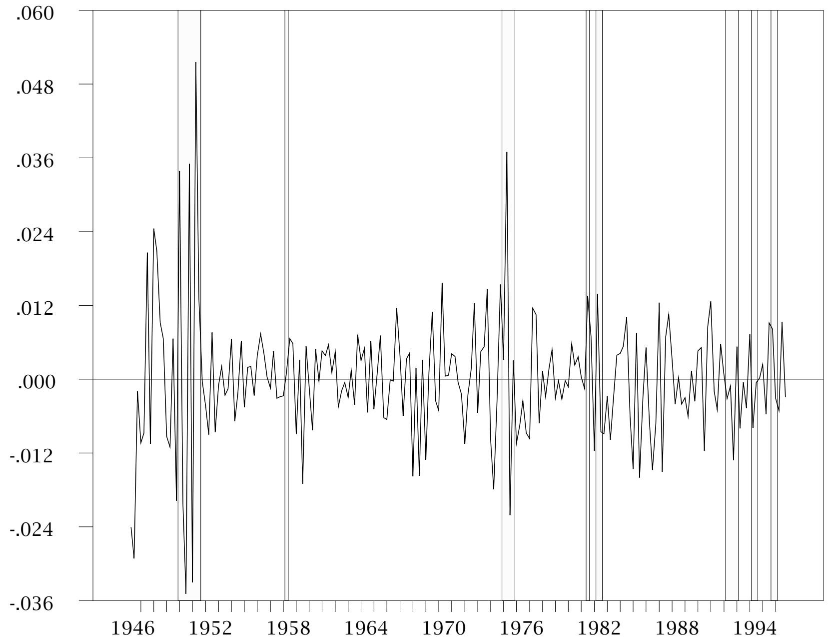
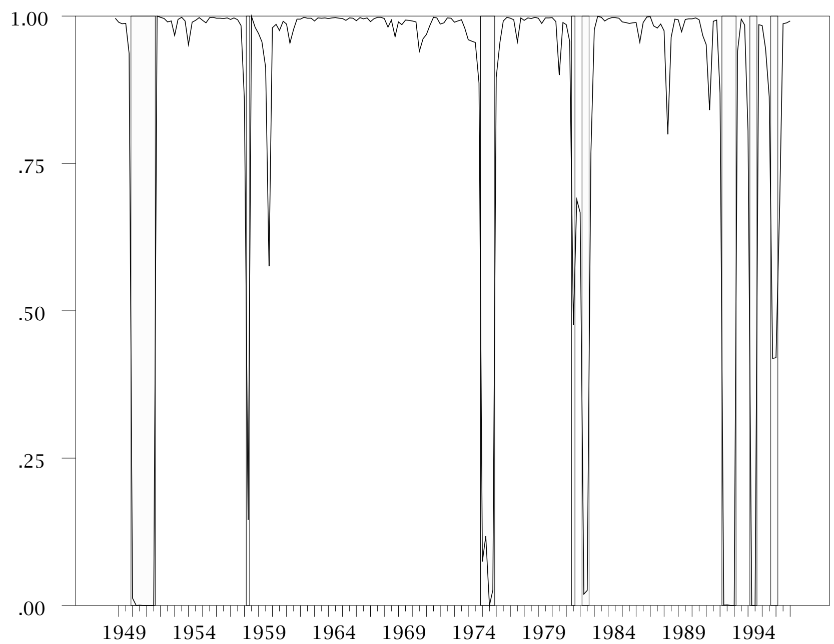


FIGURE 6: Estimated smooth probabilities of being in the intermediate regime with the estimated transition regime periods, $\Pr[s_t = 2|\mathcal{X}_T;\hat{\theta}] > 0.5$, in the shaded areas.



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