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Financial Conditions and the Money-Output Relationship in Canada

by Maral Kichian

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Abstract

We propose a drifting-coefficient model to empirically study the effect of money on output growth in Canada and to examine the role of prevailing financial conditions for that relationship. We show that such a time-varying approach can be a useful way of modelling the impact of money on growth, and can partly reconcile the lack of concensus in the literature on the question of whether money affects growth. In addition, we find that credit conditions also play a role in that relationship. In particular, there is an additional negative short-run impact of money on growth when credit is not readily available, supporting the precautionary motive for holding money. Finally, money is found to have no effect on output growth in the long-run.

JEL classification: E44, E51
Bank classification: Monetary aggregates; Credit and credit aggregates; Business fluctuations and cycles

Résumé

Au moyen d'un modèle doté de coefficients pouvant varier au fil du temps, l'auteure étudie empiriquement l'effet de la monnaie sur la croissance de la production au Canada et examine le rôle des conditions financières dans cette relation. Elle montre que l'emploi de coefficients variables peut être utile pour modéliser l'incidence de la monnaie sur la croissance et contribuer à clarifier le débat en cours à ce sujet dans la littérature. L'auteure constate également que les conditions du crédit jouent un rôle dans la relation entre monnaie et croissance. Plus précisément, la monnaie a à court terme un effet négatif additionnel lorsque le financement n'est pas facilement accessible, les agents conservant alors des liquidités par mesure de précaution. À long terme, la monnaie s'avère sans influence sur la croissance de la production.

Classification JEL : E44, E51
Classification de la Banque : Agrégats monétaires; Crédit et agrégats du crédit; Cycles et fluctuations économiques

1 Introduction

Despite the large number of studies that have empirically examined the issue of whether changes in money have any impact on output growth, a consensus is yet to emerge in the literature on this issue. This is the case whether we look at the conclusions from studies using reduced-form setups, including ones that apply causality tests and others that examine the forecasting role of money, or on the basis of the outcomes from various structural models.

There can be many reasons for the obtained mixed results, including the use of a single-equation structure versus a set of equations, whether to adopt a linear or non-linear framework, the choice of the monetary aggregate, the application of any detrending methods, the sample period selected, as well as whether structural breaks are accounted for. For example, in the latter regard, all of the recent studies that also conduct sub-sample analysis find evidence of a change in the more recent periods, and in particular a decrease in the effect of money on output. Moreover, conclusions can also be affected by the possible omission of state-contingent effects that can impart an occasional role to money for output growth. One such example, which we discuss below, is the possible role of the prevailing financial environment.

In this paper we propose a drifting-coefficient time-varying-parameter framework to analyze the impact of money on output growth and to try to reconcile some of the contradictory conclusions. Our modelling choice is motivated by two main concerns. First, we want to cast the question of interest within a setting that is general enough to accommodate non-linear features. In particular, we would like to consider changes in the money-output relationship that may have been gradual or somewhat gradual. Second, we would like to simultaneously also consider the possible role of financial conditions, notably access to credit by individuals, for changes in this relationship. Despite their plausibility, to the best of our knowledge these dimensions have not yet been jointly considered in the empirical literature, and we will show that accounting for them allows for a better characterization of the money-output relationship in Canada.

A number of studies have discussed the fact that the money-output relationship has changed over time and that this might be linked, among other things, to financial conditions. For instance, Boivin, Kiley, and Mishkin (2010) explain that considerable changes have taken place over the last thirty years in the way financial markets operate and in the conduct of monetary policy, and discuss how some of these changes may have affected inflation and output. Alvarez and Lippi (2009) show that financial innovations such as increases in the number of bank branches or ATM terminals affect payment patterns of consumers, while Jermann and Quadrini (2009) relate the increased financial activity and the financial deregulation to the moderation in GDP observed since the mid-eighties in many industrialized countries. In addition, Jermann and Quadrini (2010) show that tightening of firms' financial conditions contributed to the recent 2007-2008 recession, and that both the 1990-91 and 2001 recessions were also affected by changes in credit conditions. Guerron-Quintana (2009) also partly attributes the 'Great Moderation' to the role that financial innovations may have played, mainly because of decreased portfolio balancing costs that simultanoeusly also generated a different link between money aggregates and output. Similarly, using an endogenous business cycle model with credit shocks, Szilard, Gillman, and Kejak (2008) show that money velocity can be affected not only by productivity shocks, but also by money growth and credit shocks. They also show that, while shocks to the money supply growth rate impact velocity more during periods of high inflation, credit shocks play the bigger role during periods of deregulation, and the two types of shocks have opposite effects on output growth. Finally, Telyukova and Wright (2008) discuss the fact that households likely keep some relatively liquid assets available for contingencies where it is costly or difficult to get credit, and using a theoretical model show why making access to credit difficult renders money useful.

The above-mentioned works, as well as the recent financial crisis that resulted in frozen credit markets and necessitated quantitative easing by central banks to achieve an impact on output, demonstrate a possible credit-contingent link between money and output. That is, some changes might have occured in the money-output relationship because of the prevailing credit conditions. The literature has shown evidence of a decrease in the effect of money on output in the more recent periods, but there is no a priori reason to assume that all the changes to the relationship of interest would have occurred abruptly and simultaneously, as sub-sample analysis implictly supposes. For example, Table 1 in Alvarez and Lippi (2009) shows that financial innovations affected payment patterns of Italian consumers relatively gradually over the 1993-2004 period and also somewhat diversely.

Our proposed time-varying-parameter empirical setup in this paper is very flexible. It allows for changes that may have been more or less gradual, and that may have simultaneously or partially affected various parameters of the model. It can also account for the moderation in GDP growth by capturing the observed heteroskedasticity in the variance of GDP[1]. Finally, it allows us to parsimoniously study the potential role of the availability of credit for a stronger or weaker money-output relationship over time. With these various non-linearities integrated into the model, statistical testing can be undertaken to confirm or refute their validity, whereas omitting one or more relevant such features from the model from the outset would bias parameter estimates and affect conclusions drawn for the money-output relationship.

In the next section we undertake an extensive review of the relevant empirical literature on the topic, pertaining specially to Canadian and US data. Section 3 presents the data and results of some correlation analyses. Section 4 explains the nonlinear methodology that we apply, as well as how we integrate the role of credit conditions parsimoniously within the money-output nexus. It also presents the related results and discussion. Section 5 offers some conclusions.

2 Literature Review

Among the early works on the topic is the seminal work by Sims (1980b) who shows for U.S. data that money Granger-causes output in a reduced-form model that includes money, output, and prices, but that when interest rates are added to the model, the statistical evidence is no longer supportive of the causality hypothesis. Similar issues are raised in Sims (1980a) where business cycles are examined pre- and post-war in relation to money. These two works prompted others to look at the sensitivity of causality test results along other dimensions, also with U.S. data. For instance, Eichenbaum and Singleton (1986) note sensitivity to the considered sample period. They show, for models based on alternative business cycle theories, that tests tend to reject the causality hypothesis when post-80 observations are added, but not when the sample ends before 1980.

Model specification is also shown to matter for causality test outcomes. Using U.S. data, Christiano and Ljungqvist (1988) focus on non-standard distributional theory and on test power issues, conducting their analysis in a bivariate specification of output and money. They conclude in favour of Granger-causality hypothesis. Stock and Watson (1989) point

[1]Although mathematically different processes, with different modelling implications, both GARCH-type and time-varying parameter approaches have been shown to capture well conditional heteroskedasticity present in the finite-sample data.

out the additional role played by any trends that might be present in the data. They find that when money growth (notably M1 growth) is detrended around a linear trend, it is found to Granger-cause output even with post-80's data. Furthermore, they show that the same conclusion holds even when interest rates are included in the empirical specification, though the explanatory power of money in this case is somwehat lower.

Friedman and Kuttner (1993) replicate the previous study extending the data to 1990 but replacing the Treasury Bill rate that was used by Stock and Watson (1989) with the commercial paper rate or an interest rate spread. They find little evidence in favour of money-growth causality. Similar results are obtained when they quadratically-detrend money growth. On the other hand, when Vilasuso (2000) replicates the Stock and Watson (1989) exercise using data through 1996 and the commercial paper rate for the interest rate variable, but allows for a break in the linear trend of money growth, he concludes in favour of Granger-causality.

Additional papers studying the money-output relationship, notably within vector autoregression (VAR) frameworks, include McCallum (1979), Bernanke (1986), Blanchard and Quah (1989), King and Watson (1992), as well as Thoma (1994). Again, overall conclusions cannot be drawn as some of these studies find against the hypothesis that money Granger-causes output while others find for it.[2] But while these studies focus more on the short-run implications of money for output, others focus more on the long-run relationship between money, income, prices, and interest rates. For example, Hafer and Kutan (1997) use quarterly and annual data, and find evidence for a common stochastic trend among the four variables. They conclude that money (more precisely, M1) does not Granger-cause income, though Swanson (1998) questions the validity of the test method that was applied in this case.

For his part, Swanson (1998) uses ten- and fifteen-year rolling windows, a multitude of econometric models including cointegrated specifications, as well as increasing window subsamples to test the money-output causality. He finds that, with monthly U.S. data, both M1 and M2 have predictive power for output provided the data sample is long enough to properly characterize a cointegrating relationship among the variables of interest. However, he also points out that results are dependent on the type of test that is applied. In particular, predictive accuracy tests that rely on a best chosen model among available alternatives

[2] See also Meltzer (1999), Nelson (2002), and Feldstein and Stock (1993).

provide the more favourable outcomes compared to Wald-based tests applied within VAR models.[3]

The idea of exploiting long-run relationships among economic variables was also used in research at the Bank of Canada. For example, Adam and Hendry (2000) propose a vector error-correction model linking M1 and output in Canada, where money plays a forecasting role. Similarly, Gauthier and Li (2006) propose a three-equation vector error-correction model (known as BEAM) that represent a money market equilibrium, a stock market-output long-run relationship, and an arbitrage relationship between short- and long-term bonds. Superneutrality is not imposed and the model is found to have some predictive power for output.[4] The finding that money is a useful predictor for output in Canada is confirmed by Hassapis (2003) who uses kernel-based estimators to find a relationship between various financial variables and output. He concludes that real M1, along with bond and equity yield spreads, have explanatory power for movements in output.[5] The opposite conclusion had been arrived at in an earlier study by Cosier and Tkacz (1994) who had found that including the term spread among the explanatory variables of a model diminishes the predictive ability of real M1 for output. Finally, it should be noted that Dufour and Tessier (2006), using the causality tests proposed in Dufour and Renault (1998), report evidence for causality between money and output at fairly long horizons.

The evidence from Thoma (1994) and Swanson (1998) suggests that the causal relationship between money and output may vary over time. Psadarakis, Ravn, and Sola (2005) propose a VAR model with time-varying parameters where parameters change stochastically according to a Markov chain, and where the time variation reflects changes in Granger-causality between money and output. An application to postwar U.S. quarterly data shows that causality patterns have changed over time when M1 or M2 aggregates are used. In particular, M2 growth is shown to have a causal link to output between 1970 and 1983, while it is M1 growth that has such a link before 1970 and around the early 1990s.

[3]Swanson (1998) notes that if the true data-generating process is a vector error-correction models, then Wald-based tests on differenced data may be biased. At the same time, he also states that the surplus-lag Wald test that he applies likely has low power in finite samples if cointegration of unknown form is assumed.

[4]Given an almost decade-long era of stable inflation within a well-defined target range, a potential issue in this model is the assumption of an I(1) process for inflation.

[5]For a survey on which real and financial variables are useful predictors of output, see notably Stock and Watson (2003).

Research conducted at the Bank of Canada also focused on the possible instability in the money-output relationship. Longworth (1997) uses quarterly data, a VAR model, and increasing-window rolling samples to study the explanatory capacity of narrow and broad monetary aggregates for output in Canada. He finds that M1 growth is able to explain movements in GDP over the 1976 to 1994 period. The data is extended in a subsequent paper by Longworth (2003) and the exercise is repeated, yielding similar conclusions as the previous study.

Chan, Djoudad, and Loi (2006) examine the predictive capacity of some alternative M1 aggregates in relation to output across time. This follows from the role of financial innovations in banking products such as ATMs and the elimination of reserve requirements in Canada in the early 1990s (see Aubry and Nott (2000)) that blur the distinction between demand and notice deposit accounts. Using simple two-state regime-switching models, they find evidence of regime changes in the money-output relationship. In particular, they find that while growth in real M1 is a better indicator for output growth before 1992, growth in M1+ works better thereafter.[6]

More recently, Berger and Osterholm (2009) follow the suggestion in Chao, Corradi, and Swanson (2001) to use out-of-sample rather than in-sample based tests to examine Granger causality, and use Bayesian VARs to re-assess the money-output relationship for U.S. quarterly data. They find strong evidence that money (in this case, M2) Granger-causes output over the 1960 to 2005 period up to horizons of two years. However, they also indicate that after the mid-1980s, at the time of the 'Great Moderation' the Granger-causal role of money for output vanishes.[7]

In essence, and based on the reduced-form studies cited above, the answer to the question 'does money matter?' is largely predicated on the model specification adopted, including how variables are detrended, the monetary aggregate that is used, and on the particular sample of data that is considered. At this stage it is informative to turn to the evidence from more structural approaches.

Optimization-based small macroeconomic models, including dynamic stochastic general equilibrium (DSGE) set-ups, have been the backbone of macroeconomic analysis over the

[6] The authors also indicate that the regime change is likely very persistent.

[7] See Sims and Zha (2004) for the identification of early 1984 as the most likely date for start of the Great Moderation.

last twenty years or so. In this respect, monetary aspects of the business cycle model have been examined notably by Rotemberg and Woodford (1997), Estrella and Mishkin (1997), McCallum and Nelson (1999), Rudebusch and Svensson (2002), Woodford (2003) and Ireland (2004). None of these models find a direct role that is played by money for the equilibrium behaviour of other key economic variables. For instance, Rotemberg and Woodford (1997) do not include monetary aggregates in their model, McCallum and Nelson (1999) and Rudebusch and Svensson (2002) include a money demand equation only so as to determine money supply in equilibrium, while Woodford (2003), using a calibrated money in the utility function (MIU), finds only a small effect of real money balances on the U.S. economy.

Rather than imposing no effect from real money balances to output, Ireland (2004) considers a model that allows for this possibility. He proposes an MIU-type small microfounded model where the impact of real money balances shows up in both the IS and the Phillips curve equations. The model also takes into account the fact that the measure of money used should adjust for shifts in money demand that come from a Central Bank's management of short-term interest rates. Ireland (2004) estimates the model using maximum likelihood on quarterly post-80s U.S. data, and where the money measure is given by the M2 aggregate divided by the GDP deflator. As with the previously-mentioned structural studies, he finds no separate role for real money balances, either in the aggregate demand curve or in the aggregate supply equation. Similarly, Estrella and Mishkin (1997) find that after the 1980s, there is no longer a predictive role of money for output due to the substantial variability in the velocity of money.

However, once again the above findings have been challenged by Favara and Giordani (2009) and Guerron-Quintana (2009) who, while adopting very different structural methodolgies, come to the opposite conclusion. In particular, Favara and Giordani (2009) impose the restrictions suggested by New Keynesian monetary models in a VAR model with shocks to monetary aggregates. They then test the theoretical predictions of the model using block exogeneity tests and impulse response analysis on quarterly data for the U.S. over the 1966–2001 period. Consistent with previous studies, applications over the more recent 1980-2001 period yield a smaller effect of money for output, however these effects remain significant. Interestingly, their results hold regardless of whether M1, M2, or M3 is used. Finally, the authors generate artificial data from their VAR model assuming an important effect of money balances on the remaining variables of the model. They find that the estimation of Ireland's

(2004) model with this data does not find the imposed effect of money demand shocks.

Another study by Dorich (2009) considers the role of the estimation method for the conclusions from Ireland (2004). Using a slightly-modified version of the latter, Dorich (2009) focuses on only two of its equations, namely the IS and LM curves, and applies generalized method of moments (GMM) joint estimation. The limited-information estimation approach that imposes less restrictions than the full-information maximum likelihood approach gives more chance for the model to succeed with the data. Estimates show that real balance effects (based on the M2 measure; linearly detrended) on GDP are quantitatively important in the U.S. over the 1959 to 2004 period. He also finds that the effect has declined in the 1980-2004 period, and attributes the decline in the output volatility in the U.S. in part to this smaller money effect.

For his part, Guerron-Quintana (2009) proposes an optimization-based model where households can endogenously divide their money purchases into money for consumption (cash) and money for savings (deposits), and where re-adjusting the portfolio is costly. This yields heterogeneity in households and a money velocity that is partly forward-looking, reflecting their expectations regarding interest rate movements. The author argues that financial innovations in the banking sector decreased portfolio balancing costs by an important amount, and that the resulting link between money aggregates and output in the model is also able to capture the 'Great Moderation'. Estimating the model pre- and post- 1984 with quarterly U.S. data and using the real M2- monetary aggregate, he finds that both the short- and long-run semi-elasticities of demand decline in the more recent period, (from 3.0 and 16.7, to 0.42 and 4.7, respectively) and that the frequency of portfolio re-optimization drops as well, from 6 to 3 quarters.[8]

3 Correlation Analysis

Our data is for Canada. It is in quarterly frequency and extends from 1976Q1 to 2010Q1. To get a preliminary sense of comovements, we start by documenting the correlation properties over time between selected monetary aggregates and output growth. We define output growth (y_t) as the percentage annualized change in quarterly real GDP. For our monetary variables,

[8]See also Mertens (2007) for the role of financial innovation on the monetary transmission mechanism in the U.S.

we use the narrow money aggregate M1 plus (M1+), as well as two broad money aggregates, namely M2 plus (M2+) and M2 plus plus (M2++). Nominal M1+ is constituted mainly of currency and of chequing deposits. Nominal M2+ also includes term deposits, life insurance, money-market mutual funds, as well as deposits at government institutions. As for the M2++ variable, it adds to M2+ Canada Savings Bonds and non-money market mutual funds. Real counterparts of these variables are also obtained by dividing each nominal aggregate by the consumer price index. Finally, growth rates of money aggregates are generated by taking the percentage annualized change in the quarterly levels. We adopt the notation m_t as our generic definition of money growth throughout the text. For convenience, we provide charts (Figures 1 to 3) that show the evolutions of our nominal money growth variables along with output growth.

3.1 Correlations Across Two Sub-samples

To see whether money has any leading properties for output, we examine the correlation between output growth at time t and money growth from one up to eight quarters earlier. We look at results based on the full sample, as well as two subsamples corresponding roughly to the pre- and post- inflation-targeting eras, namely 1976Q1 to 1989Q4, and 1990Q1 to 2010Q1[9].

Table 1 reports the results. We first notice that, for all the samples considered, we can reject the null of no cross-correlation between growth at time t and m_{t-j} for some money aggregates and for lags 1 to j for particular values of j. Furthermore, the test is sometimes significant for all eight lags taken together. However, for other monetary aggregates, we find no evidence of cross-correlation. Second, we see that this cross-correlation is changing over time, since the correlation pattern is not always the same over the two subsamples, or over the full sample.

The results over the entire sample notably show evidence for cross-correlation between growth and lags of money when M1+ or M2+ are considered, both nominal and real. In addition, in the case of M1+, lags one up to eight are found to be significant. In contrast, we find that lags of M2++ do not co-move with current output growth, suggesting no role for this aggregate in time-series models of Canadian output.

[9]Inflation targeting officially started in Canada in 1991.

Table 1: Cross-correlations (y_t, m_{t-k})

up to k lags	$M1+$	$M2+$	$M2++$	Real $M1+$	Real $M2+$	Real $M2++$
	1976:1 to 2010:1					
1	y	n	n	y	n	n
2	y	n	n	y	n	n
3	y	y	n	y	n	n
4	y	y	n	y	n	n
5	y	y	n	y	n	n
6	y	y	n	y	y	n
7	y	y	n	y	y	n
8	y	y	n	y	y	n
	1976:1 to 1989:4					
1	n	n	n	y	y	y
2	y	n	n	y	y	y
3	y	n	n	y	n	n
4	y	n	y	y	n	n
5	y	n	y	y	n	y
6	y	y	y	y	n	n
7	y	y	y	y	n	n
8	n	y	n	y	n	n
	1990:1 to 2010:1					
1	y	y	n	y	y	n
2	y	y	n	y	y	n
3	y	y	n	y	y	n
4	n	y	n	y	y	n
5	n	y	y	y	y	n
6	n	y	y	y	y	n
7	n	y	y	y	y	n
8	n	y	y	y	y	n

Tests of no correlation are conducted between time t output growth and a given monetary aggregate growth over $t-1$ to $t-j$ periods. A significant test at the 5 per cent level is denoted by 'y' for yes. Non-significance of the test is denoted by 'n' for no.

An examination of sub-samples reveals a slightly different picture. In this case, all of the considered aggregates seem to co-move at certain lags with output, including nominal and real M2++. In the pre- inflation-targeting period, M1+ seems to co-move the most, followed by M2++ and then M2+. On the other hand, in the inflation-targeting period, there is evidence that, whether nominal or real, M2+ has co-moved the most with output (at up to all eight lags considered). Real M1+ also shows a similar pattern to the previous case, while lags in the first difference in nominal M1+ move together with current output growth only at nearer horizons, namely at lags one up to three. Finally, the null of no cross-correlation is not rejected when real M2++ is considered[10].

3.2 Rolling Sub-Sample Correlations

To get a sense of how smooth these changes in correlation have been, in Figure 4 we plot the (y_t, m_{t-1}) correlations using the M1 plus Canadian money aggregate and 10-year fixed rolling windows. In the Figure, a given value at a quarter t is the calculated correlation over the $t + 39$ sample. Test p-values for the null of no correlation over the subsample are also plotted (shaded series in the Figure).

From here we can see that the correlation parameter evolves quite a bit over time, registering values as high as 0.47 (over the 1988-1998 period) and as low as -0.03 (over the 1999-2009 period), and changing gradually over some parts of the sample and more abruptly over others. Moreover, we find there are subsamples over which the null of no correlation can be rejected at the 5 per cent level. This is the case, in particular, over the successive subsamples from 1976-1986 to 1977-1987 and from 1979-1989 to about 1982-1992, where the correlation varies around an average of 0.34, from 1988-1998 to about 1991-2001 where an initial increase in correlation to about 0.43 is subsequently followed by a gradual decrease to values of around 0.30, as well as from approximately 1994-2004 to 1995-2005 where the correlation increases again to reach 0.40 but declines relatively sharply to about 0.28 soon after. In contrast, we do not have evidence that a significant correlation (at the 5 per cent level) exists between growth in M1 plus and growth in output over the successive subsamples from 1982-1992 to 1987-1997, and from 1996-2006 to 1999-2009.

[10] One reason for why the correlation pattern is changing over time, not explored here, could be that Statistics Canada has made changes in the actual definitions of some of the components constituting the various monetary aggregates.

Admittedly, such basic two-dimensional statistics can only offer limited insight into the money-output dynamics and should not be over-interpreted, however we do get a sense from this figure that the relationship has been evolving over time, and that some of the changes have occurred gradually and others more abruptly.

3.3 Linear Models

The above analysis was based on a simple two-dimensional framework, with no consideration given to other economic variables that likely intervene in the money-growth relationship and considerably enrich the analysis (see the literature review cited above). In this section, we consider multivariate linear equations to study whether money has predictive capacity for growth.

We consider the class of models given by:

$$y_t = a + \sum_{i=1}^{I} b_i y_{t-i} + \sum_{j=1}^{J} c_j m_{t-j} + \sum_{k=1}^{K} d_k X_{l,t-k} + e_t \tag{1}$$

where $X_{l,t}$ represent predetermined variables that in previous studies have been shown to have explanatory power for explaining movements in Canadian growth. These include U.S. growth rates, the term spread (defined as the 10-year bond yield minus the 3-mth T-bill yield), as well as the first difference in Canadian male employment.[11] Regressions are carried out using the above-mentioned nominal or real monetary aggregates, and over full and sub-sample periods. Estimations are first conducted using lags of all variables except the monetary aggregate, and then including also lags of the latter. In all cases, we use $I = 5$, $K = 5$, and $J = 8$ lags. The terms that are not significant at the 5 per cent level are then discarded and the corresponding results are recorded below in Tables 2A (for the nominal aggregate cases) and 2B (for the real aggregate cases).

We see that including lags of a particular monetary aggregate contributes sometimes to the dynamics of output growth, and when it does, based on the improvement in the adjusted R-square, its effect is only marginal. Furthermore, this effect changes over time, as can be seen from the results obtained on the different sub-samples. In this respect, the first sub-sample produces little evidence for monetary aggregates being helpful in predicting changes

[11] Experimenting with other predetermined variable choices yielded qualitatively similar or worse overall fit.

Table 2A: Linear Multivariate Models with Nominal Money Aggregates

Model	Sum of y_t coefs	Sum of m_t coefs	Credit dummy coef.	$\overline{R}^2$
	1976:1 to 2010:1			
Without M	0.66	-		0.48
With M1+	0.64	0.09 (lag 1)		0.51
	1976:1 to 1989:4			
Without M	0.08	-		0.61
With M2++	-0.47	-0.32 (lag 4)		0.48
	1990:1 to 2010:1			
Without M	0.51	-		0.58
With M1+	0.50	0.18 (lags 1,7)		0.62
With M2+	0.36	-0.18 (lag 8)		0.61

in future growth.[12] In contrast, we find that changes in M1+ have a significant but small positive impact on output in both the second sub-sample, and in the full sample, regardless of whether this aggregate is measured in real or nominal terms. Changes in M2+, on the other hand, are found to have a significant negative effect (with nominal M2+ in the more recent sub-sample, and with real M2+ in the full sample).

While the models above are somewhat informative, it remains that they are linear. Thus, they are ill-suited to deal with the presence of possible non-linearities as discussed in the previous paragraphs. We address such features in the next section.

4 Non-Linearity and the Role of Credit

As discussed in the introduction and in the literature review sections, financial shocks, both in the form of financial innovations and of changes in credit conditions, have been suggested to have affected output and to have influenced the relationship between money and output. In particular, Jermann and Quadrini (2009) link the increased financial activity and the financial deregulation to the moderation in GDP while Jermann and Quadrini (2010)

[12] Changes in nominal M2++ do have a significant effect over this period but the adjusted R-square actually declines in this case.

Table 2B: Linear Multivariate Models with Real Money Aggregates

Model	Sum of y_t coefs	Sum of M_t coefs	Credit dummy coef.	$\overline{R}^2$
	1976:1 to 2010:1			
Without M	0.66	-		0.48
With M1+	0.60	0.07 (lag 1)		0.51
With M2+	0.55	-0.11 (lag 6)		0.49
	1976:1 to 1989:4			
Without M	0.08	-		0.61
	1990:1 to 2010:1			
Without M	0.51	-		0.58
With M1+	0.52	0.09 (lag 7)		0.60

show that the tightening of firms' financial conditions contributed to the recent 2007-2008 recession, and that previous recessions were also affected by changes in credit conditions in the economy. In addition, Telyukova and Wright (2008) explain that households keep liquid assets in case credit becomes costly or difficult to access, which is what makes money relevant for te economy. Furthermore, Guerron-Quintana (2009) shows that financial innovation and deregulation, having led to decreased portfolio balancing costs, can change the link between money aggregates and output, which in turn can partly explain the 'Great Moderation' in the US.

In addition to the potential credit-contingent role of the money-output relationship, from the previous sections we also have convincing evidence on the changing impact of money on output in Canada. Furthermore, we would like the data to tell us when and where those changes have been gradual or more abrupt, and we would also like to account for the conditional heteroskedasticity observed in the volatility of output. All of these characteristics can be suitably and parsimoniously captured in the flexible drifting-coefficient modeling approach. We thus consider the class of time-varying-parameter (TVP) models given by:

$$y_t = \beta_{0t} + \beta_{1t} m_{t-1} + \beta_{2t} y_t^* + \beta_{3t} i_{t-1} + \gamma dum_t + \epsilon_t \tag{2}$$

with

$$\beta_{jt} = \beta_{j,t-1} + v_{jt}, \qquad\qquad j = 0, \ldots, 3. \tag{3}$$

where the money aggregate term is given by M_t, and where the other two regressors in the equation are variables that in previous studies were shown to have explanatory power for explaining movements in Canadian growth. Thus, y_t^* represents US output growth while i_t refers to the long-short term spread[13]. The coefficients $\beta_{j,t}$ of the model have a time subscript and vary over time according to driftless random walk processes. The error terms ϵ_t and v_{jt} are all assumed to be uncorrelated, independent and normally distributed. Finally, a variable dum_t is included in the model and is assumed to have a fixed coefficient. This is a dummy variable that is aimed at capturing a possible additional impact of money on output when credit is hard to come by. The dummy is thus set to one if the change in credit in period $t-1$ is less than some critical value C. The dummy is then multiplied by m_{t-1}, the growth in the monetary aggregate in period $t-1$. In other words, we allow for an additional fixed effect of money at time $t-1$ on output growth at time t when credit conditions at time $t-1$ are difficult.

We consider two alternatives for our change in credit variable, namely the change in short-term bank lending to businesses and the change in total household credit. The former is motivated by studies such as Jermann and Quadrini (2010) that have examined the role of firms' financing constraints. We also consider the impact of tightness in household financing given the discussion in Telyukova and Wright (2008) that households keep relatively liquid assets available for contingencies in case it becomes costly or difficult to get credit (for example via credit card debt), which is exactly when money becomes relevant. As for the critical value C below which credit growth is considered to be low, we use either the mean of a given series over the data sample minus one or two standard deviations. For the business credit variable, which is the more volatile series, we also consider negative growth rates, while for the smoother household credit series, we also consider values below the mean.

TVP models can capture a number of features that might be present in our data[14]. They

[13]For robustness, we also consider instead of the term spread the 3-month Canadian treasury bill rate, as well as spreads between various grade bond yields and the government 90-day treasury bill rates. The former produced qualitatively somewhat similar results to the term spread while the latter yielded convergence problems and counter-intuitive results with no role whatsoever for financial conditions

[14]For two examples of studies using this type of approach, see Kichian (2001) and Boivin (2006).

can permit more or less gradual changes in the effects of the various regressors on growth and they can also allow for differing timings and directions in these changes. In addition, they can capture conditional heteroskedasticity in the dependent variable, coherently accounting for the observed decrease over time in the volatility of output growth.

Model estimation is not standard but is feasible once the system of equations is cast in a state-space framework. Then, maximum likelihood estimation via Kalman filtering can be applied and a measure of the evolution of the time-varying coefficients can be obtained. Moreover, the TVP model can be tested against an equivalent model with fixed coefficients using the likelihood ratio (LR) statistic. In the tables below (Table 3, 4A and 4B), and for computational convenience, we will refer the obtained statistics to χ^2 cut-off points. However, those results should only be interpreted as being suggestive and not statistically conclusive. Recent work by Bernard, Dufour, Khalaf, and Kichian (2012) shows that the null of no-parameter variation notably implies a nesting-at-the-boundary issue, and that regularity conditions underlying classical assumptions may fail in such cases. The study instead advocates the use of Maximized Monte Carlo-based procedures to undertake statistical testing, as these methods are immune to the raised concerns[15].

We start by estimating the TVP model with no fixed effects (i.e, imposing $\gamma = 0$) for the various monetary aggregates at our disposal. The results are reported in Table 3 and generally seem to suggest that there is no need to include time-variation in the parameters.

Table 3: LR statistics for Tests of TVP Models with No Credit Effects

	M1+	M2+	M2++	Real M1+	Real M2+	Real M2++
Spread	1.62	5.56	2.51	3.01	4.46	8.45*
T-bill	1.76	0.56	5.76	2.49	1.32	6.27

The Table reports likelihood ratio test statistics for tests of a given time-varying-parameter model against its fixed-parameter null. One star designates a significant test outcome at the 10 per cent level ($\chi^2(4) = 7.78$) and two stars, a significant test at the 5 percent level ($\chi^2(4) = 9.49$).

We now also include the dum_t variable in the TVP specification. As explained above, we consider two alternatives for the credit variable and three critical values C for each one of these. We enter each of these in turn in our TVP models, write the corresponding system in state-space form, and estimate the models. We also estimate corresponding fixed-coefficient

[15]This is left for future work.

models with credit effects and calculate likelihood ratio statistics. Tables 4A (business credit variable) and 4B (household credit variable) show the results from the TVP-with-credit-effects modeling strategy.

Table 4A: LR statistics for Tests of TVP Models with Fixed Credit Effects

	M1+	M2+	M2++	Real M1+	Real M2+	Real M2++
	Change in ST Bank Lending < (mean - one se)					
LR	1.74	7.30	7.01	3.25	6.13	9.63*
	Change in ST Bank Lending < (mean - two se)					
LR	3.18	10.90**	10.42**	3.20	7.87*	9.10*
	Change in ST Bank Lending < (-one se)					
LR	3.23	11.20**	9.80**	3.42	7.53	9.09*

The Table reports likelihood ratio test statistics for tests of a given time-varying-parameter model with credit effects against its fixed-parameter null. One star designates a significant test outcome at the 10 per cent level ($\chi^2(4) = 7.78$) and two stars, a significant test at the 5 percent level ($\chi^2(4) = 9.49$).

Abstracting from the particular monetary aggregate used, and in contrast to the conclusions drawn based on Table 3, all of the reported results are suggestive of a TVP modelling approach with an additional role for money that is contingent on tight credit conditions. These outcomes are thus compatible with Jermann and Quadrini (2010), Guerron-Quintana (2009), Szilard, Gillman, and Kejak (2008), and Telyukova and Wright (2008) in that financial shocks do influence the money-output relationship that also evolves over time.

Looking at the results more closely, Table 4A reports the outcomes for the case where short-term bank lending is used to represent credit. We see that when access to short-term credit is difficult, the results point to TVP and to a role for the prevailing financial conditions in models that use nominal (and in one case real) broad aggregates.

A similar picture can be obtained when we examine results obtained using the household credit variable reported in Table 4B. Again, for some monetary aggregates, the outcomes suggest time-variation in the model parameters and an additional role for money that is contingent upon the prevailing availability of credit conditions. These outcomes are notably obtained using the nominal broad aggregates, and appear more favourable with the M2+ measure. Interestingly, the M2++ aggregate in real terms leads us to somewhat similar

Table 4B: LR statistics for Tests of TVP Models with Fixed Credit Effects

	M1+	M2+	M2++	Real M1+	Real M2+	Real M2++
	Change in Total Household Credit < its mean					
LR	4.08	6.45	8.83*	5.03	5.14	8.72*
	Change in Total Household Credit < (mean - one se), spread variable used					
LR	5.62	14.55**	6.74	4.26	6.85	9.70**
	Change in Total Household Credit < (mean - one se), tbill variable used					
LR	6.39	12.19**	9.26*	4.02	7.46	9.44*

The Table reports likelihood ratio test statistics for tests of a given time-varying-parameter model against its fixed-parameter null. One star designates a significant test outcome at the 10 per cent level ($\chi^2(4) = 7.78$) and two stars, a significant test at the 5 percent level ($\chi^2(4) = 9.49$).

conclusions.

Table 5A: TVP Coefficient Estimates with ST Bank Lending Credit Effects

	se(ϵ_t)	se(const)	se(ΔM_t)	se(y_t^*)	se(i_t)	γ
	Nominal M2+, C is (mean - two se)					
Estimate	1.0961	0.0003	0.0858	0.1517	0.0369	-0.2825
	Nominal M2++, C is (mean - two se)					
Estimate	1.1870	0.0007	0.0720	0.1667	2.2e-26	-0.3254
	Nominal M2+, C is (- one se)					
Estimate	1.0866	0.0014	0.0884	0.1502	0.0369	-0.2848
	Nominal M2++, C is (- one se)					
Estimate	1.1969	1.1e-11	0.0732	0.1629	0.0006	-0.2947

Table 5A documents the coefficient estimates for the cases when the test, referred to the is χ^2 cut-off point, is found to be significant at the 5 per cent level. We see that estimates are fairly similar across the different models[16]. In all cases, the coefficient on the money growth term has an estimated standard deviation varying between 0.07 and 0.09, around half the estimated values for the volatility displayed by the impact of the US growth rate on Canadian

[16] In two of the reported cases, we see the classical bunch-up at zero issue for the estimated standard errors, however this does not seem to be an important problem given the overall similarity of the results and the fact that these same standard errors appear to be better estimated in the other model versions.

growth, and higher than the volatility in the effect of the spread on growth. Importantly, the estimated additional impact of money during periods of tightness in the growth rate of short-term bank lending is economically sizeable and has the expected negative sign, with γ estimated in the range of -0.28 and -0.33.

Table 5B: TVP Coefficient Estimates with Household Credit Effects

	se(ϵ_t)	se(const)	se(ΔM_t)	se(y_t^*)	se(i_t)	γ
	Nominal M2+, C is (mean - one se), i_t is the spread					
Estimate	1.0690	0.0008	0.0933	0.1303	0.0007	-0.3654
	Real M2++, C is (mean - one se), i_t is the spread					
Estimate	1.2507	0.0655	0.0883	0.1282	0.0002	-0.1623
	Nominal M2+, C is (mean - one se), i_t is the t-bill					
Estimate	1.0072	0.2267	0.1033	0.0918	0.0431	-0.3956

Table 5B documents the coefficient estimates for the significant test cases (again, according χ^2 criterion) when household credit is used. Again, we find that for all the monetary aggregates considered in the Table, the coefficient on the money growth term has an estimated standard deviation in the range of 0.09-0.10, similar to those reported in Table 5A. The remaining coefficient standard error estimates are also somewhat comparable across the different specifications. Thus, the US growth rate is estimated to have a more time-varying impact on Canadian output than the interst rate variable. In addition, and as was the case with short-term lending credit, here also we see that the credit-tightness effect has the expected negative sign and seems to be economically relevant (ranging between the values of -0.16 to -0.40).

Taken together the above results suggest there is some merit to the reasoning that the impact of money on output evolves over time, and that during times when access to credit is more difficult (whether it is for businesses or for households), money is hoarded by agents causing an additional drag on output growth in the following quarter. This is the case only when broad money aggregates are used, regardless of the credit variable adopted. Therefore, the components in the broad aggregates additional to the narrow money variable appear to be playing a role in these results. This warrants more investigation and is left for future versions.

4.1 The Estimated Coefficient Time Paths

Taking the first example from each of Tables 5A and 5B, we plot the estimated measures of the time-varying coefficients of the model. For the case where credit is represented by short-term business lending, we thus focus on the TVP model with nominal M2+ where the interaction dummy is set to one when changes in the growth rate of the credit variable are smaller than the mean of the series minus two standard deviations. For the case where credit is represented by household credit, the selected TVP specification is with nominal M2+ where the interaction dummy is set to one when changes in the growth rate of the credit variable are smaller than the mean of the series minus one standard deviation.

Figures 5A-8A depict the estimated paths of the four drifting coefficients from the short-term business credit-based specification, while figures 5B-58 plot the evolution of the estimated coefficients from the model that relies on the household credit series. From these, we see that there have been important fluctuations over time in these coefficients, with certain changes having been small and gradual and others having been larger or relatively more abrupt. In addition, and as expected, all the changes seem not to have occured at simultaneous episodes. We also note that, except for the graphs depicting the evolution of the coefficient of US growth on Canadian growth (shown in Figures 7A and 7B), coefficient paths obtained from the alternative credit series are quite similar.

Looking first at the plots of the time-varying drift coefficients β_{0t}, Figures 5A and 5B), we see that there has been a fair bit of movement in this parameter over time. The graphs show some cyclical features, with dips during periods of recessions (around 1992-1993, in 2001, and again in 2008-2009), and with booms when output growth expanded importantly (for example following the 1992-1993 recession period). The fact that these characteristics have been captured by the estimates lends some assurance to the general usefulness of the modelling strategy. The figures also show a slow and sustained decline in the value of the drift over time, trending down from a high of 2.5 in 1993-1994 to values of around one by 2010. One reason for this observation could be a decline in Canadian productivity which has also been pointed out in the literature (see, for example, Baldwin and Gu (2008).

The effect of the time-varying coefficient of the spread term on output growth (β_{3t}) also appears to have been quite variable over time (Figures 6A and 6B). Since the variable is meant to capture the degree of uncertainty regarding long-term economic prospects, it is not surprising that its impact on output growth is higher during periods of some economic turbulances. Thus, it is high during periods of recession, as is the case for 1991-1992 and again during, and subsequent to, the financial-crisis-induced recession period. The impact of the uncertainty also rose during the 1998-1999 period around the introduction of the Euro and expectations of its repercussions for worldwide markets.

Turning now to the coefficient on the US growth rate (β_{2t}, Figures 7A and 7B), we first note that the effect of US growth on Canadian growth has always been (not surprisingly) positive (the average estimated impact is about 0.8 based on the business-credit-based specification, and it is 0.6 based on the household-credit-based model). However, we also note episodic and sustained swings away from that value. The business-credit-based specification shows that changes in US growth affected Canadian growth almost one-for-one during the period 1995 to 2002, whereas the estimate based on the household-credit model shows an average impact of around 0.80 from about 1992 to about 2002. Interestingly, a certain amount of decoupling seems to have occurred between the two economies from around 2003, consistent with the opening up of the emerging economies to world markets, but following the recent financial crisis, growth in Canada seems to have strongly re-united with growth prospects in the United States.

Finally, we turn to the coefficient on the change in the M2+ aggregate (β_{1t}, Figures 8A and 8B). In the same graphs we also depict those episodes when the dummy term for credit growth was designated a non-zero value by our 'credit tightness' criterion. We first note that changes in the impact of money growth on output growth have been sometimes more gradual and at other times fairly abrupt. In addition, while the average impact of money is found to be centered at zero, we also see that there have been episodic and relatively-sustained swings away from that value into positive or negative territories. For example, from Figure 8A, we find that the estimated effect of money growth on output was negative during the 1991-1992 recession period, as well as the period a little preceding and subsequent to the recent financial crisis. It was also negative between about mid-1994 to around 1998, a period that witnessed the Mexican peso crisis of 1994, the Asian crises in 1997, as well as the early days of the US invasion of Iraq in 2003. At the same time, there are periods where money growth has a positive effect on output growth. This is the case, for example, from the period starting in early 1998 and ending in mid-2001, as well as over the period mid-2003 to early 2006.

If money is hoarded during periods of current or expected future uncertainty, then increases in money growth, all things equal, should lead to a negative impact of money on output growth. We can discern such episodes in the data: for example, from the fourth quarter of 1991 to the third quarter of 1993 when growth in broad money increased from 5.3 to 6.4 per cent, from mid-1994 to mid-1995, when it again increased from -1.4 to 5.5 per cent, and again from the mid-2008 to mid-2009, where it changed from 10 per cent to around 6 per cent, transitioning through a peak of above 16 per cent growth in the interim. Another case in point is when money growth shot up from 6.5 per cent to 12 per cent as Central banks make liquidity injections into the US financial system in response to the September 11th events. The latter occurrance, as well as the quantitative easings by Central Banks towards the end of our sample show up as events when money became specially relevant during periods where credit is difficult to come by. The bars in Figure 8A show that these periods correspond to periods of 'credit tightness' as designated by our model, and in line with the results found in Jermann and Quadrini (2010) for the US.

Figure 8B allows us to draw similar conclusions. In particular, recession periods are associated with a negative impact of money growth on GDP growth. In addition, we find that there are time periods when, despite credit tightness, the impact of money growth is positive on output. This is the case notably during the 1998-2002 period, although it also seems that the impact declined as the number of 'credit tightness' periods were increasing.

5 Conclusion

Given the mixed results obtained in the literature on the empirical link between money and output growth, their dependance on notably the chosen sample and on the money aggregate used, and given the absence of models that empirically focus on a credit-contingent role of money, we proposed a driftless-coefficient time-varying-parameter model to examine this question for Canada. We thus entertained the possibility that the conflicting evidence observed in the literature may have been due to using too-restrictive empirical setups or to omitting to account for the potential role of financial conditions on the money-output relationship. Our proposed approach could thus capture features such as gradual and differently-timed changes over time in the values of different model coefficients, conditional heteroskedasticity in output growth, and the possible role of access to credit or availability of credit for the changing impact of money on output.

Our results revealed considerable time-variation in the model parameters when broad money aggregates were used. In particular, we found that while in the long-run money growth has no effect on GDP growth, it sometimes has a negative short-term effect on output, and at other times, a positive one. These observations could be the reason for some of the obtained opposite conclusions that were arrived at in the literature using differing data samples. We noted that the negative impact episodes are mostly associated with the recession periods in our sample. Moreover, we showed that specially difficult credit conditions, as defined by various 'credit tightness' criteria, generated an additional negative effect of money on output.

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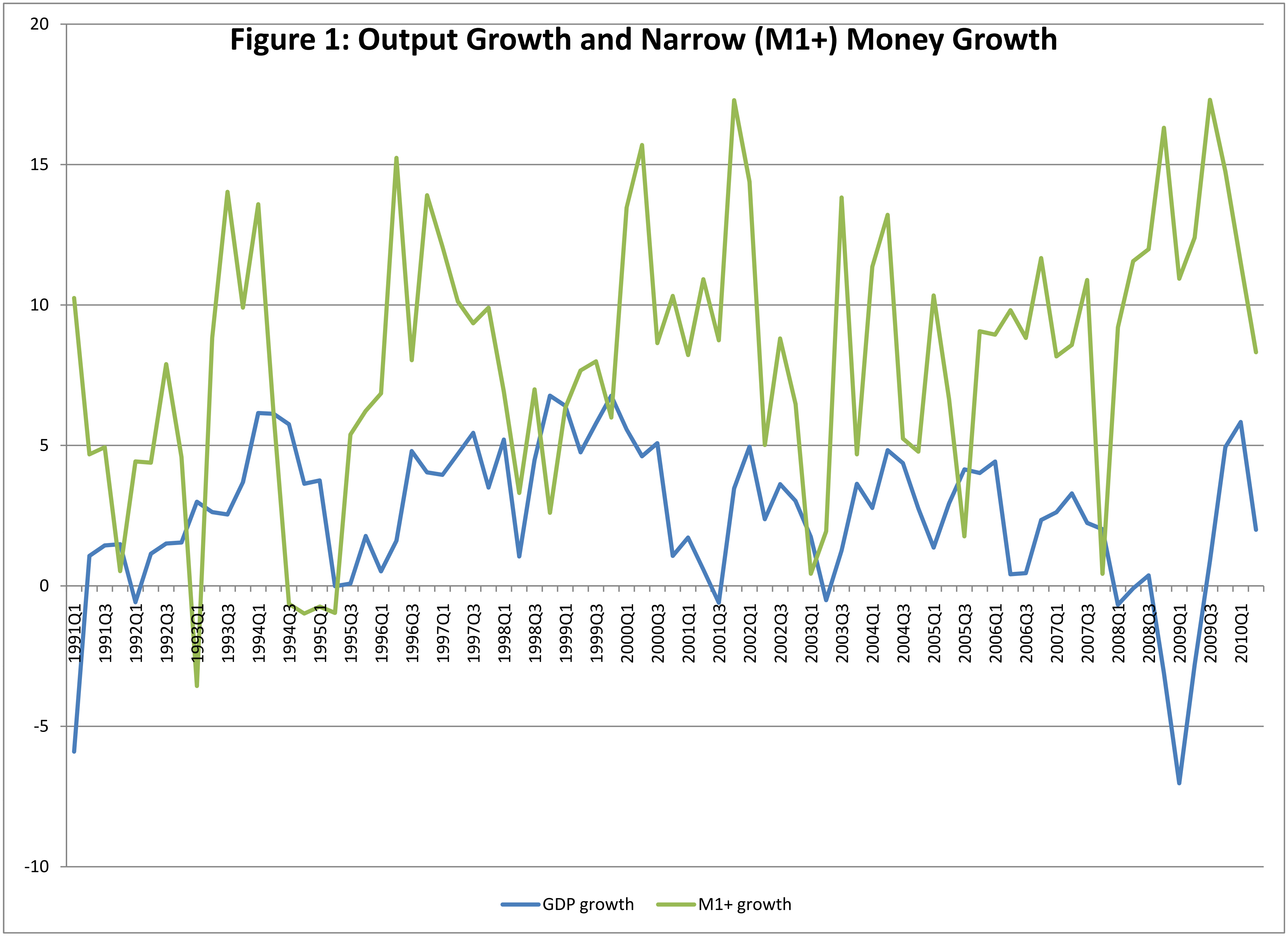
Figure 1: Output Growth and Narrow (M1+) Money Growth
20
15
10
5
0
-5
-10
1991Q1
1991Q3
1992Q1
1992Q3
1993Q1
1993Q3
1994Q1
1994Q3
1995Q1
1995Q3
1996Q1
1996Q3
1997Q1
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2010Q1
GDP growth
M1+ growth

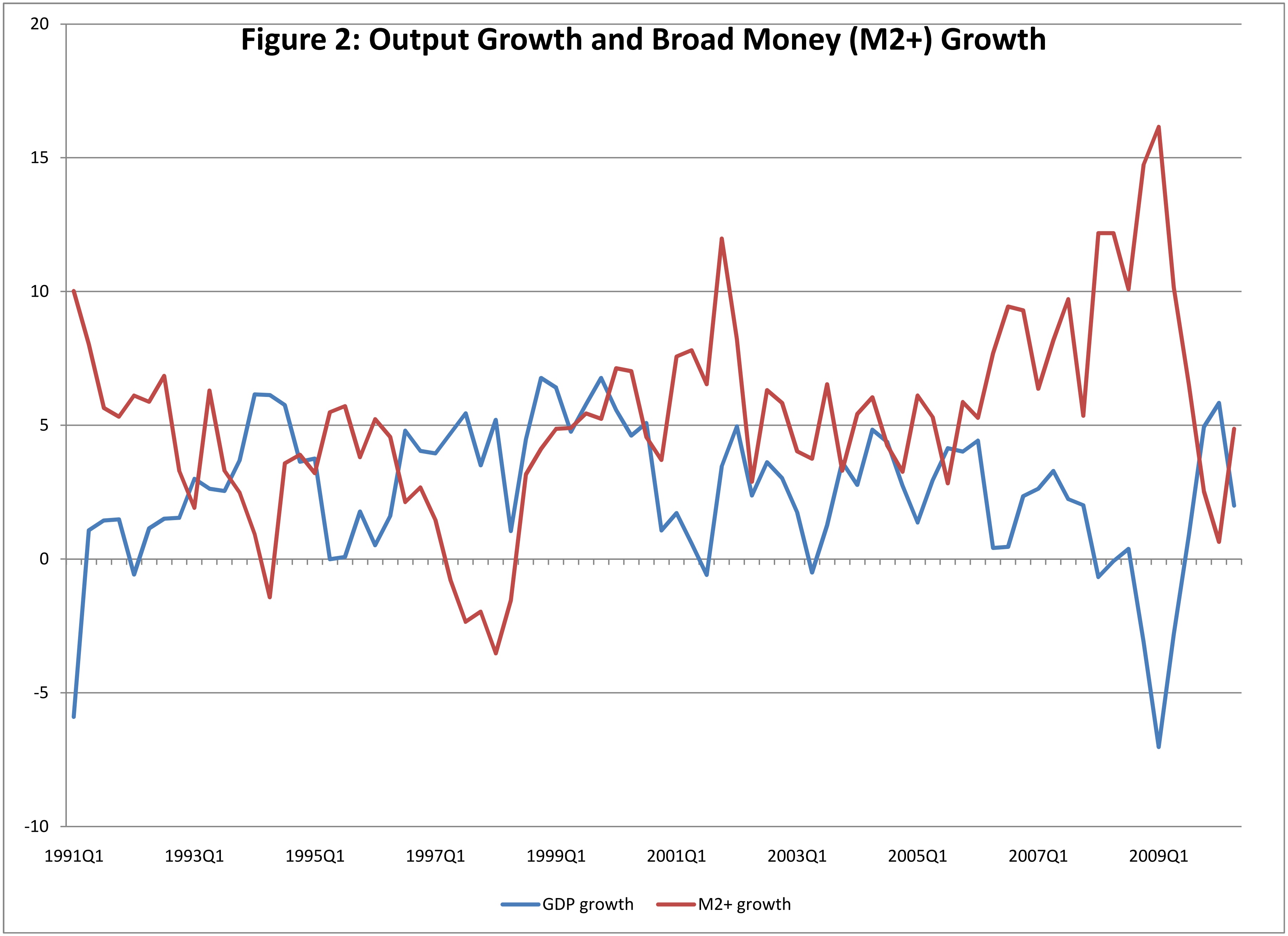


Figure 2: Output Growth and Broad Money (M2+) Growth
20
15
10
5
0
-5
-10
1991Q1
1993Q1
1995Q1
1997Q1
1999Q1
2001Q1
2003Q1
2005Q1
2007Q1
2009Q1
GDP growth
M2+ growth

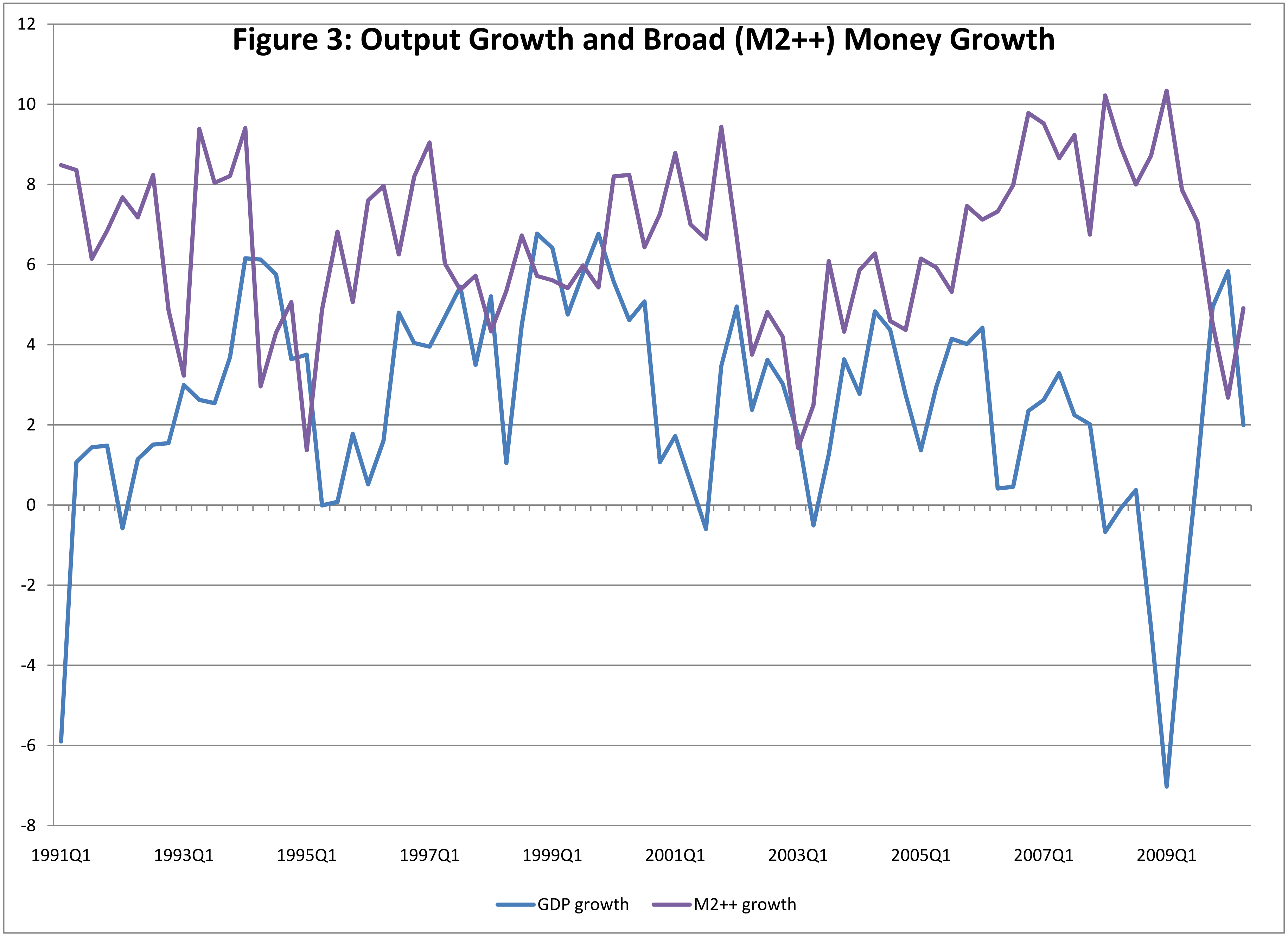
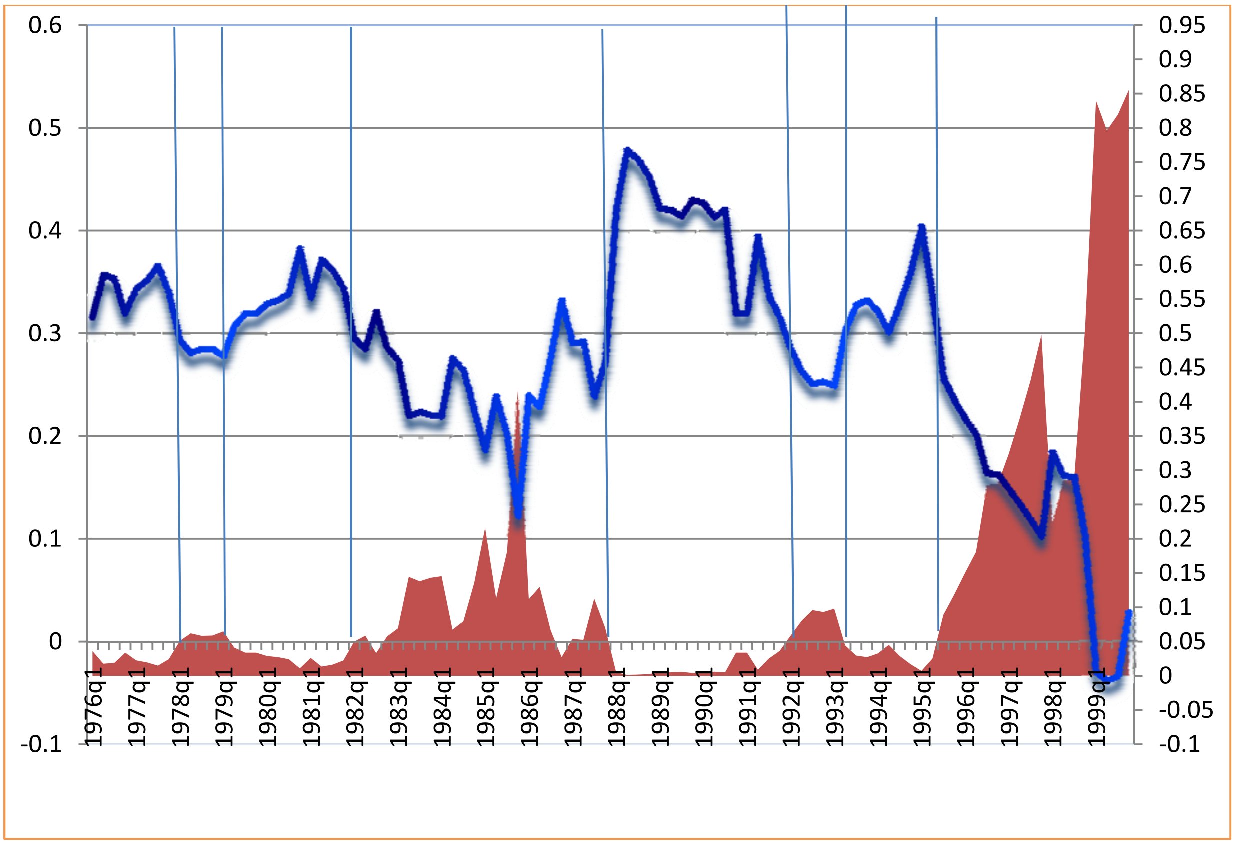


Figure 3: Output Growth and Broad (M2++) Money Growth
12
10
8
6
4
2
0
-2
-4
-6
-8
1991Q1
1993Q1
1995Q1
1997Q1
1999Q1
2001Q1
2003Q1
2005Q1
2007Q1
2009Q1
GDP growth
M2++ growth

Figure 4: M1+ Growth and Output Growth Correlations, 10-Year Fixed Rolling Windows



The left axis pertains to the correlations (solid line) while the right axis pertains to the p-values for tests of no correlation (shaded area). Thus, the money-output correlation, for example, over the 1976q1—1986q1 is significant at the 5 per cent level, while over the 1997q1—2007q1 it is not significant at the same level (p-value=0.33).

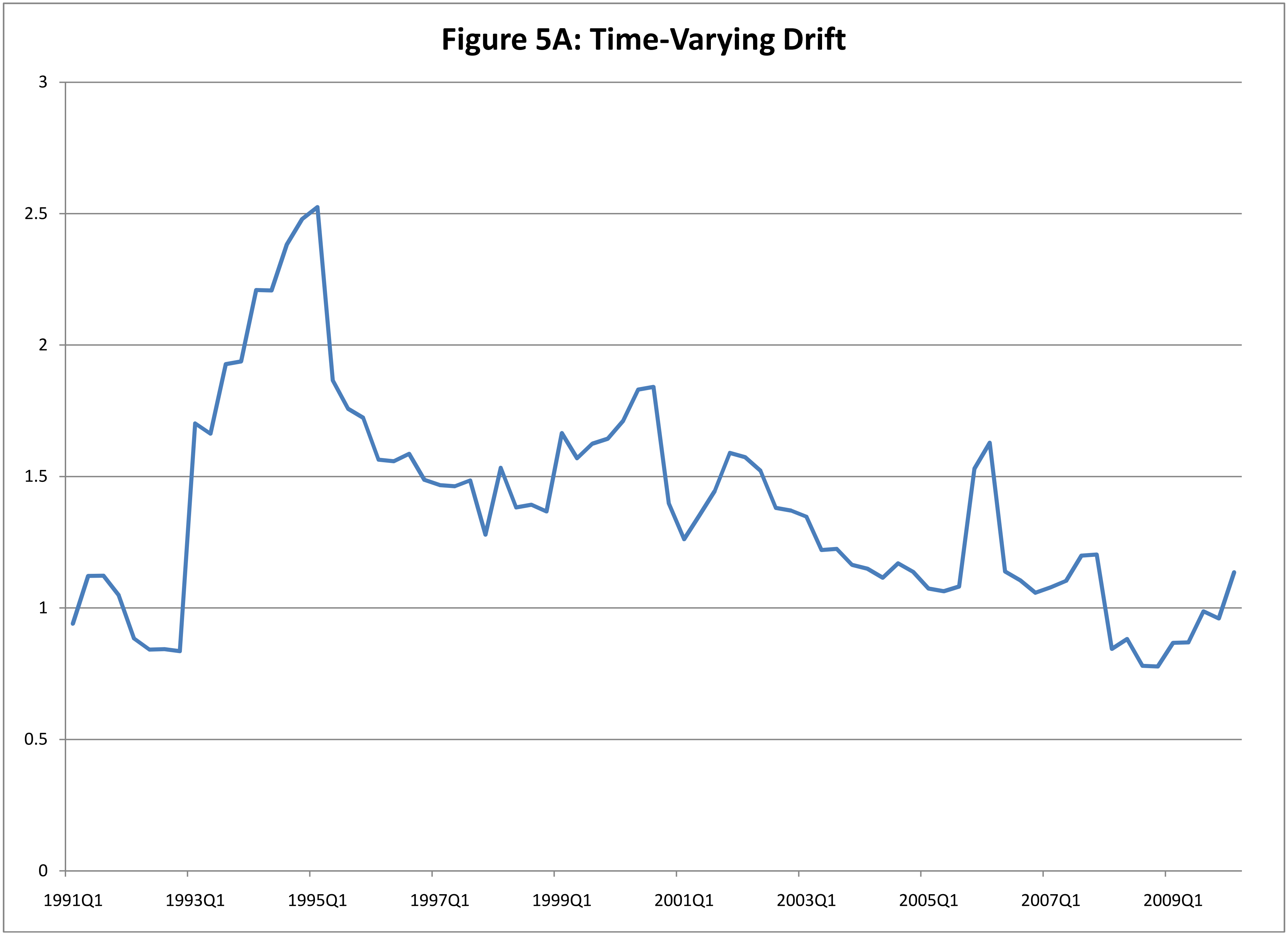


Figure 5A: Time-Varying Drift
3
2.5
2
1.5
1
0.5
0
1991Q1
1993Q1
1995Q1
1997Q1
1999Q1
2001Q1
2003Q1
2005Q1
2007Q1
2009Q1

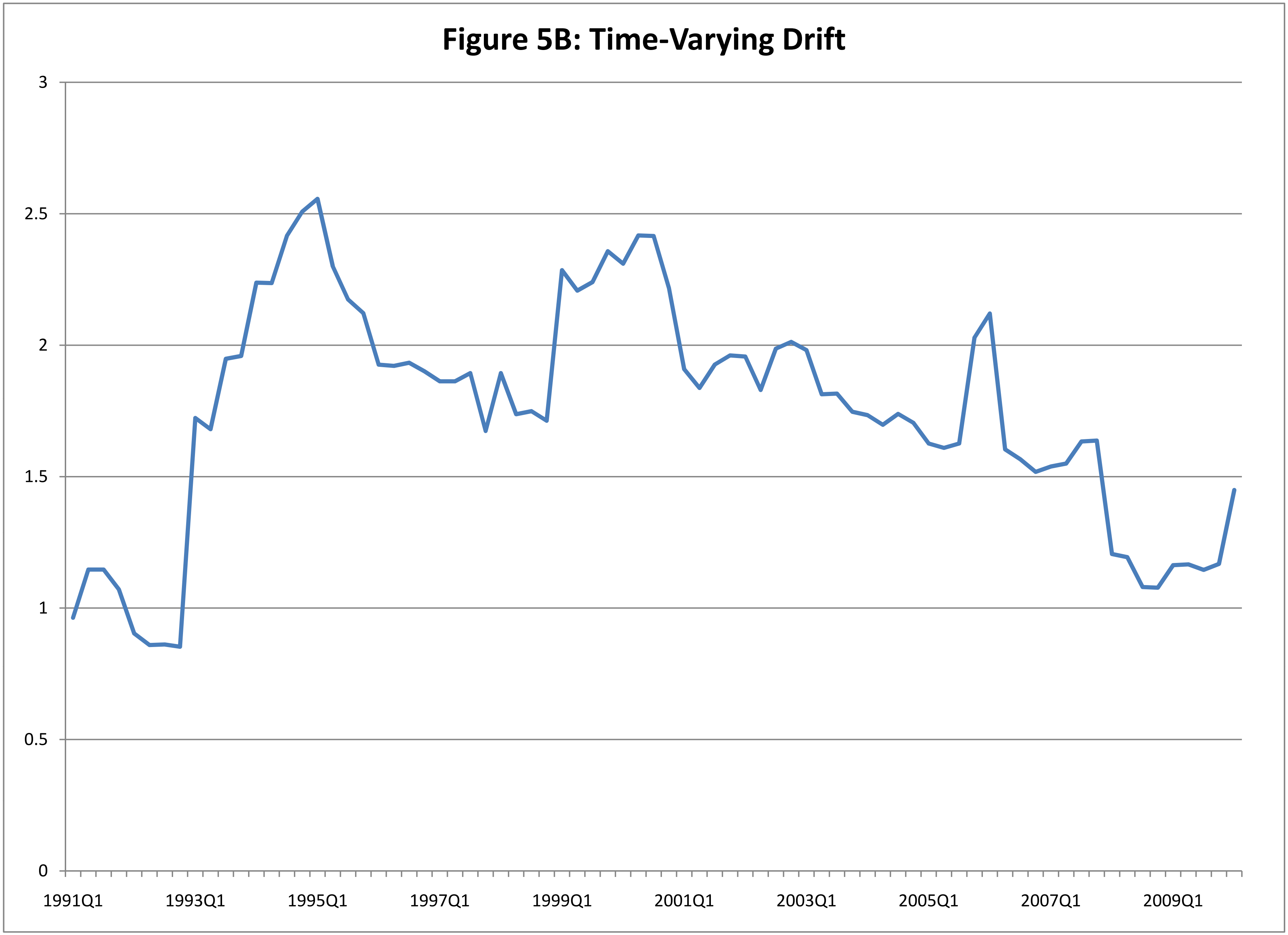
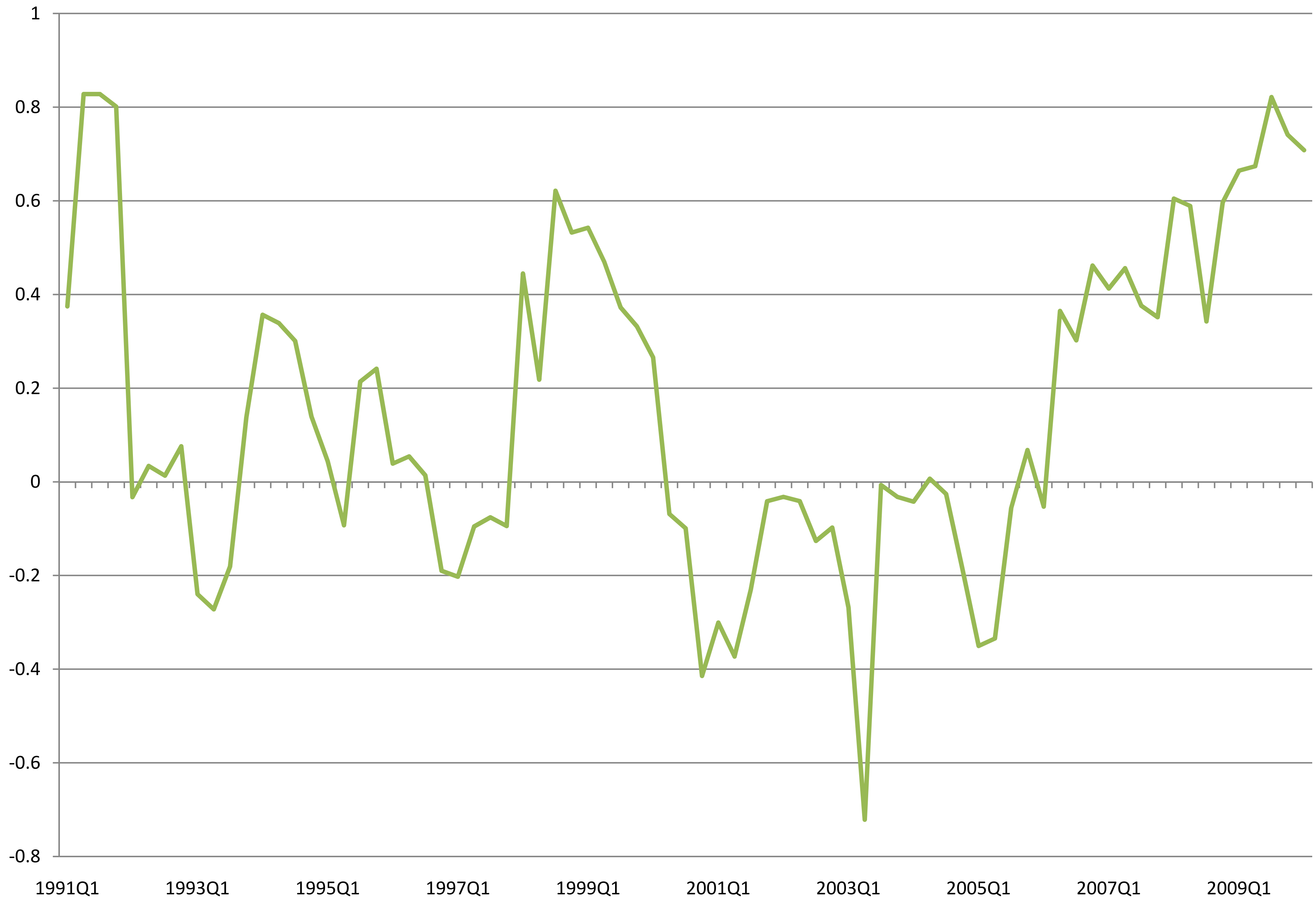


Figure 5B: Time-Varying Drift
3
2.5
2
1.5
1
0.5
0
1991Q1
1993Q1
1995Q1
1997Q1
1999Q1
2001Q1
2003Q1
2005Q1
2007Q1
2009Q1

Figure 6A: Time-Varying Coefficient on the Spread



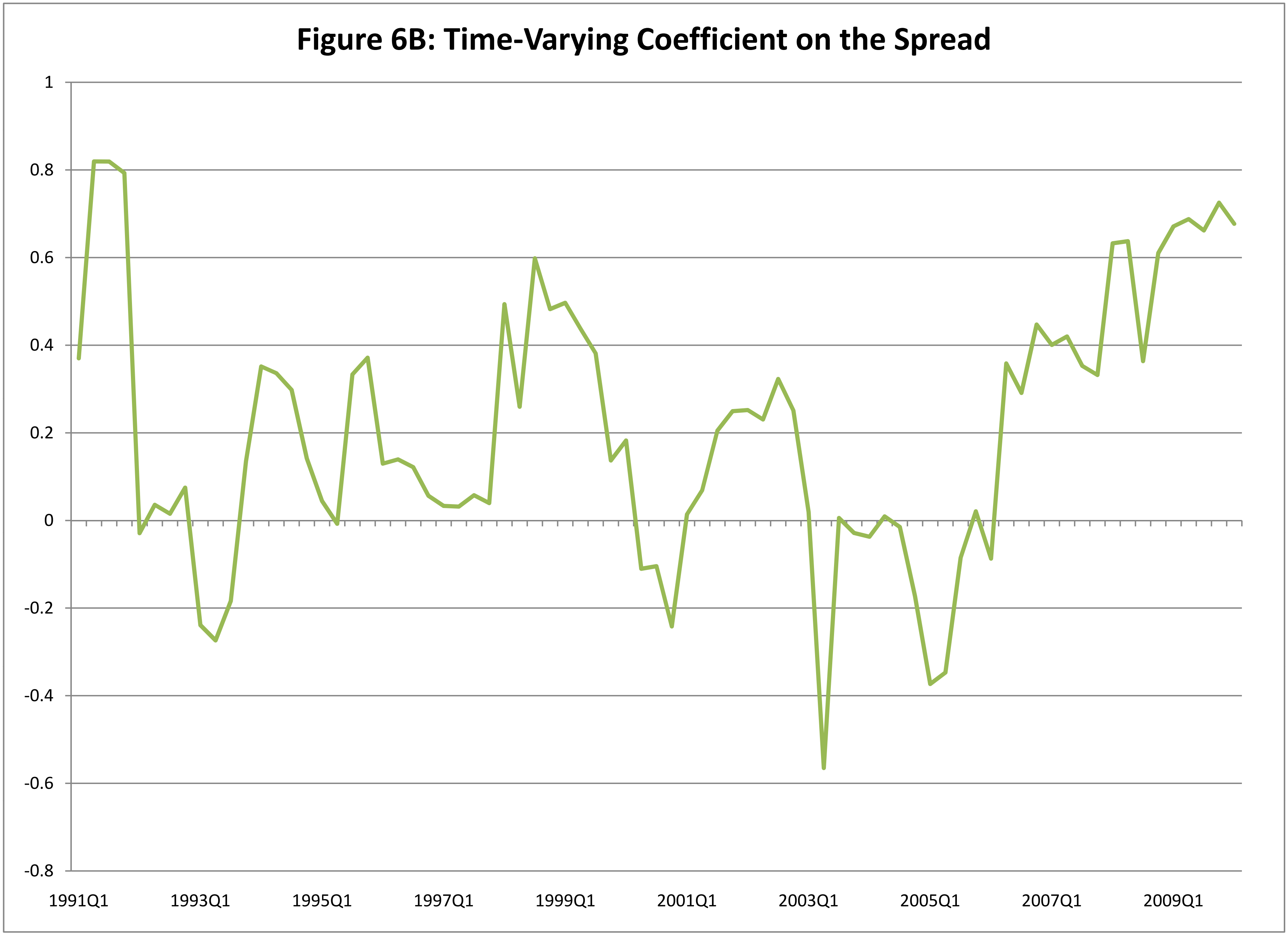


Figure 6B: Time-Varying Coefficient on the Spread
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
1991Q1
1993Q1
1995Q1
1997Q1
1999Q1
2001Q1
2003Q1
2005Q1
2007Q1
2009Q1

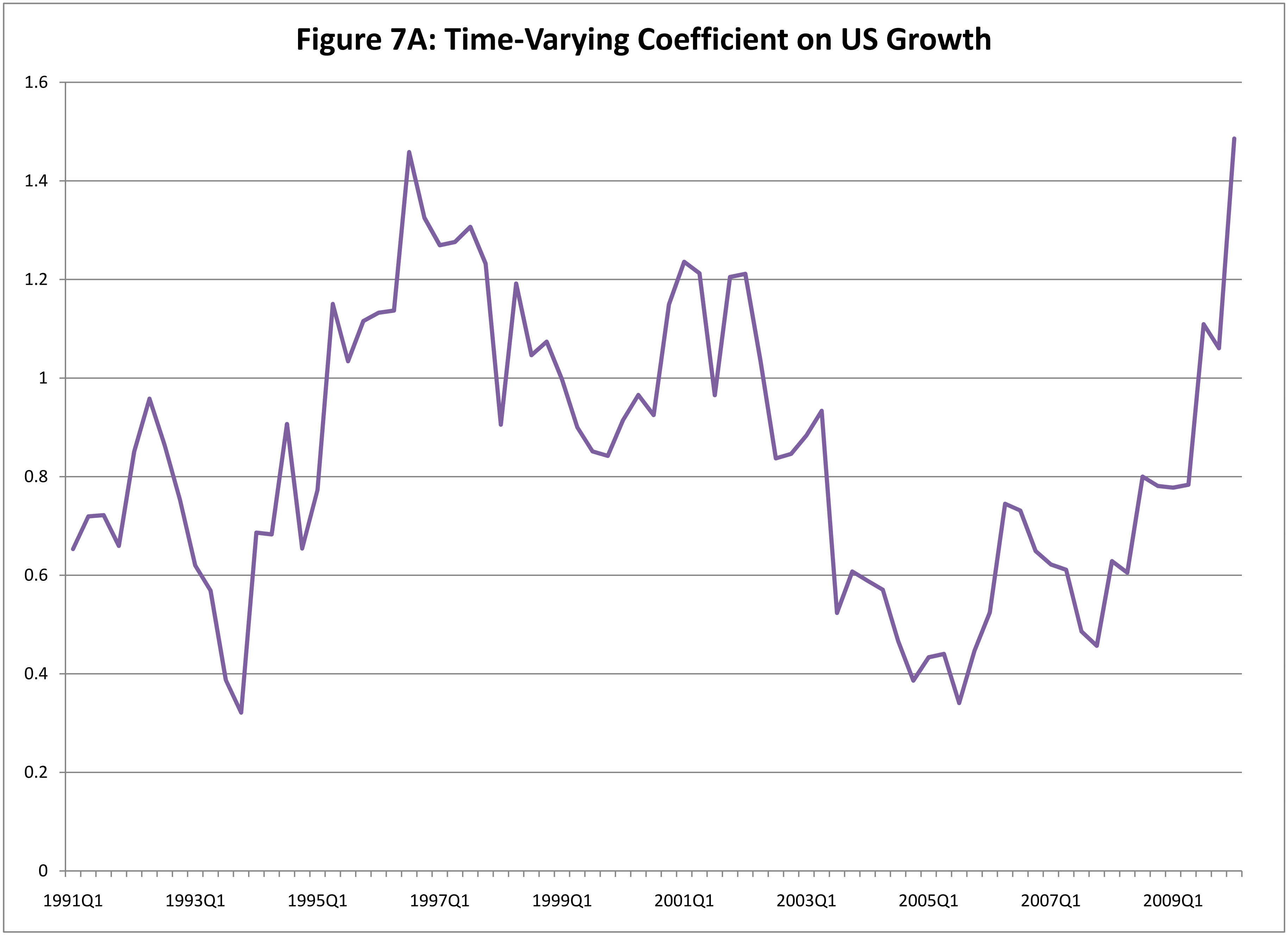


Figure 7A: Time-Varying Coefficient on US Growth
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1991Q1
1993Q1
1995Q1
1997Q1
1999Q1
2001Q1
2003Q1
2005Q1
2007Q1
2009Q1

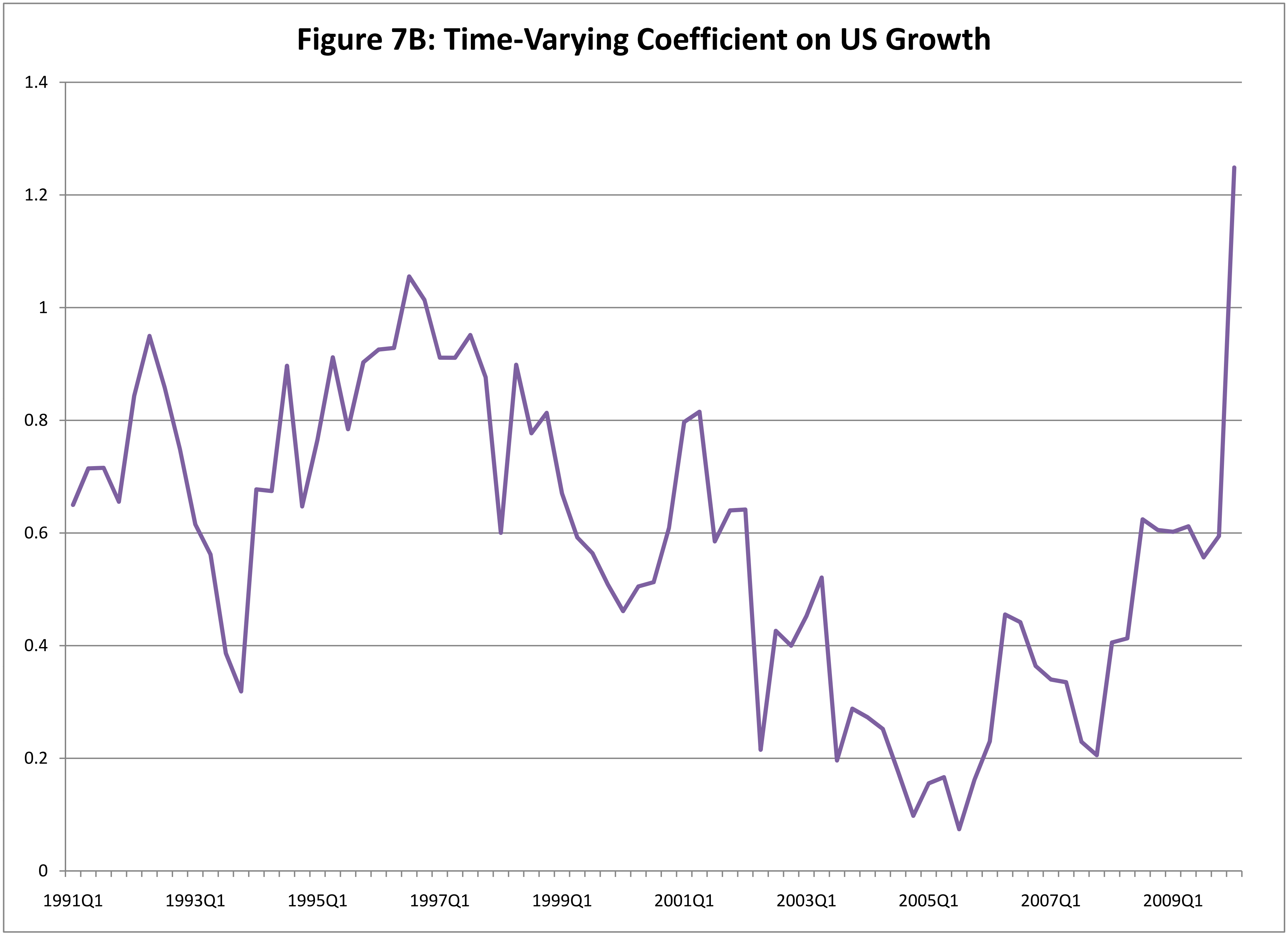


Figure 7B: Time-Varying Coefficient on US Growth
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1991Q1
1993Q1
1995Q1
1997Q1
1999Q1
2001Q1
2003Q1
2005Q1
2007Q1
2009Q1

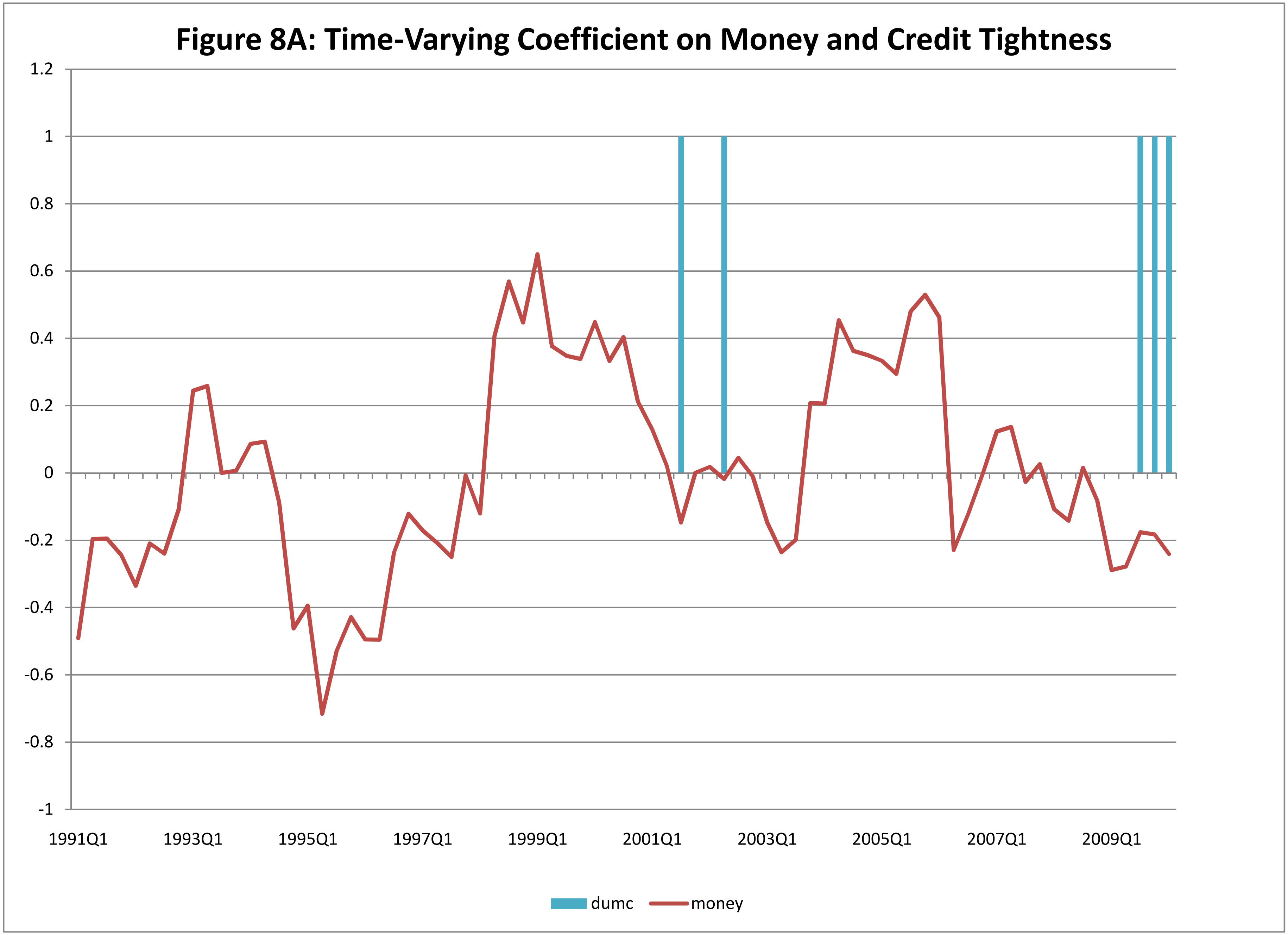


Figure 8A: Time-Varying Coefficient on Money and Credit Tightness
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
1991Q1
1993Q1
1995Q1
1997Q1
1999Q1
2001Q1
2003Q1
2005Q1
2007Q1
2009Q1
dumc
money

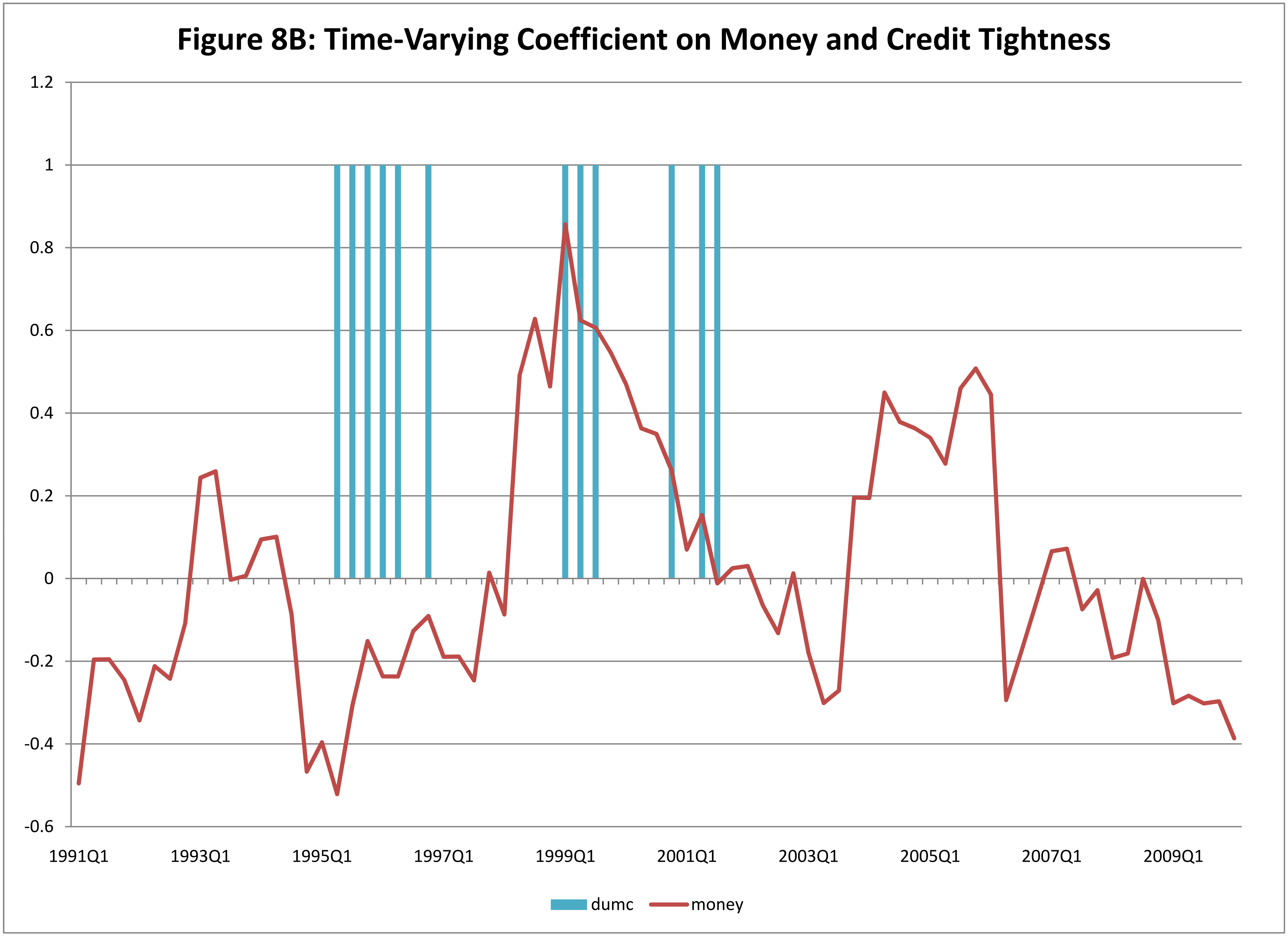


Figure 8B: Time-Varying Coefficient on Money and Credit Tightness
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
1991Q1
1993Q1
1995Q1
1997Q1
1999Q1
2001Q1
2003Q1
2005Q1
2007Q1
2009Q1
dumc
money