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Was the Bundesbank's credibility undermined during the process of German reunification?

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1. Introduction

1.1 Historical background

Monetary union in Germany as part of the reunification process required a conversion rate between the Deutschmark and the Mark, the currencies of West and East Germany respectively. Flows (in particular wages and pensions) were converted at a rate of 1:1, whilst there were different conversion rates for stocks, leading to an average conversion rate of 1:1.8.[1] During the preparation for monetary union, i.e. from February to May 1990, a serious conflict arose between the West German government and the Bundesbank. This clash centred on two issues: that the West German central bank was in favour of a gradual move to monetary union based on achieving step-by-step economic convergence and, conversely, that the West German government wanted to introduce the Deutschmark as soon as possible into East Germany, considering this step the best means to enhance economic conditions in the run-down communist country. Moreover, once it became evident that German Monetary Union was approaching – before even political reunification –, the Bundesbank expressed concerns over the stability of the Deutschmark and required a conversion rate that would not lead to inflation. By contrast, the West German government was driven principally by the desire not to harm social conditions in East Germany, combined with the necessity of proposing a conversion rate, which was politically acceptable for the East German government in the subsequent negotiations. This rationale led the West German government to suggest a conversion rate, which was rejected by the Bundesbank because of its potential for inflationary consequences.

[1] Deutsche Bundesbank, *Monthly Report*, July 1990, p. 17.

Notwithstanding earlier conflicts between government and Bundesbank[2], the events of 1990 remain unparalleled in many respects. The collision was extraordinarily severe and long lasting. Most earlier conflicts had consisted broadly of some pointed or barbed remarks by politicians over what had been seen as inappropriate interest rates set by the Bundesbank. In 1990, however, the conflict took four months to subside, and even the resignation of Bundesbank governor Pöhl in early 1991 may be seen to have been a consequence of this.[3] In addition to the length of the conflict, it was also deliberately brought to public attention: the Bundesbank explained and defended its position in press conferences, speeches, and more than 30 interviews given by members of the central bank council, thereby accusing the government of neglecting the Deutschmark's stability. Despite this struggle, the Bundesbank finally had to accept a politically rather than economically determined conversion rate.

1.2 Hypothesis and aim of the working paper

The events of 1990 thus contrast strongly with the reputation of the Bundesbank as one of the most independent central banks.[4] For this reason an exploration is conducted here as to whether the exertion of influence by the government on the Bundesbank in 1990 led to a loss of credibility and independence.

The hypothesis is that the Bundesbank lost some degree of credibility due to the conflict with the national government in 1990. The conduct of the government caused damage to the credibility of the Bundesbank and harmed confidence in German monetary policy as a whole.

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[2] C.-L. Holtfrerich, "Relations between Monetary Authorities and Governmental Institutions: The Case of Germany from the 19th Century to the Present", in: *Central Banks' Independence in Historical Perspective*, ed. G. Toniolo (Berlin, New York: 1988), pp. 144-48. H. Berger, "A State within the State? An Event Study on the Bundesbank (1948-1973)", in: *Scottish Journal of Political Economy* 46 (1999), pp. 17-39.

[3] D. Marsh, *The Bundesbank. The Bank that Rules Europe* (London: 1992), pp. 223-25.

[4] A. Cukierman, *Central Bank Strategy, Credibility, and Independence: Theory and Evidence* (Cambridge, MA: 1992), p. 382. R. Sturm, "How Independent is the Bundesbank?" in: *German Politics* 4 (1995), pp. 38-39.

It is the aim of this paper to discuss this hypothesis in three steps. The conflict between government and Bundesbank will be described and analysed from a qualitative point of view. The main analytical question will be, for what reasons could a conflict of such dimension arise in the context of the formation of a monetary union after a relatively conflict-free relationship between the two institutions over a sustained period of time. Financial market data will subsequently be used to make a quantitative assessment of the credibility loss suffered by the Bundesbank. Finally, the costs of lost credibility will be assessed.

1.3 Existing literature

The existing literature is incomplete concerning these three main points of emphasis. A quantitative analysis of the credibility problems and an estimation of the costs of lost credibility have not yet been attempted.

Even in the area of the qualitative description of the conflict, the existing literature cannot be regarded as satisfactory. It describes rather than analyses the conflict. This is principally because the majority of publications consider the conflict as a tiny piece in the larger puzzle of the economic aspects of German reunification. Therefore, note is made of the subject, but without going into it in detail.[5] In addition, two major publications are commissioned work, either by the then government[6] or by the Bundesbank[7]. Both try to downplay the conflict. However, it remains surprising that even articles and books explicitly focusing on the independence of the Bundesbank[8] or on Bundesbank – government

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[5] E. Gawel, *Die deutsch-deutsche Währungsunion. Verlauf und geldpolitische Konsequenzen* (Baden-Baden: 1994). S.F. Frowen and J. Hölscher, eds., *The German Currency Union of 1990: A Critical Assessment* (New York: 1997). T. Lange and J.R. Shackleton, eds., *The Political Economy of German Unification* (Providence, RI: 1998). P.J.J. Welfens, ed., *Economic Aspects of German Unification*, 2nd ed. (Berlin: 1996). Marsh, *The Bundesbank*, pp. 196-227.

[6] D. Grosser, *Das Wagnis der Währungs-, Wirtschafts- und Sozialunion: Politische Zwänge im Konflikt ökonomischer Regeln* (Stuttgart: 1998).

[7] M.E. Streit, "German Monetary Union", in: *Fifty Years of the Deutsche Mark*, ed. Deutsche Bundesbank (Oxford: 1998), pp. 639-81.

[8] Sturm, "How Independent is the Bundesbank?", pp. 27-40. J. Leaman, *The Bundesbank Myth: Towards a Critique of Central Bank Independence* (New York: 2000).

relations[9] do not devote the required attention to the unprecedented events. There remain only two publications analysing the conflict in some detail.[10] Their approach, however, is quite different from that presented here.

In addition to being incomplete, the existing literature also deserves critical appraisal. It describes the conflict exclusively or at least predominantly as a conflict between government and Bundesbank, thereby neglecting fundamental differences of opinion within the Bundesbank council, concerning both economic issues and the method of dealing with the government. This is regrettable, since not only the conflict itself, but also the conflict management on behalf of the central bank is crucial in determining the consequences for the Bundesbank's credibility. Therefore, this working paper attempts to fill this gap by taking more notice of interviews and speeches by Bundesbank council members offering opinions different from those of Bundesbank governor Pöhl.

This paper is based for the most part on published sources, in particular on newspaper articles from 1990. This is because all the internal sources, in particular the deliberations of the Bundesbank council, are not yet accessible. Only in some cases is analysis based on unpublished sources. These sources – principally manuscripts of speeches – were withdrawn from circulation in 1990, as the Bundesbank did not want them to be published. However, it is possible to examine them in the Bundesbank press archive in Frankfurt.

1.4 Structure of the working paper

The structure of this working paper is in accordance with the afore-mentioned steps in which the hypothesis shall be discussed.

Chapter 2 describes the conflict between government and Bundesbank, using interviews and speeches of Bundesbank council members, German and international newspaper articles, and secondary literature. The principal question

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[9] M. Duckenfield, "Bundesbank - Government Relations in Germany in the 1990s: From GEMU to EMU", in: *West European Politics* 22 (1999), pp. 87-108.

[10] E. Gawel, "Zur Neuen Politischen Ökonomie der deutsch-deutschen Währungsunion", in: *Kredit und Kapital* 29 (1996), pp. 1-31. J. Stufler, *Informationspolitik als Instrument der Deutschen Bundesbank. Dargestellt am Beispiel der deutschen Währungsunion* (Munich: 1993).

is, for what reasons could a conflict of these dimensions arise? The presentation of the peculiarities of the formation of a currency union in contrast to "normal" conflicts will lead to differentiation between independence of the central bank, on the one hand, and credibility of the monetary policy of a country as a whole, on the other. The government took only the independence of the Bundesbank into consideration, whilst the Bundesbank itself was concerned over the credibility of German monetary policy. It will be argued that this difference of opinion was at the heart of the conflict.

Chapter 3 approaches the loss of credibility for the Bundesbank from a quantitative point of view. Subchapter 3.1 shows that conventional measurements of central bank independence have no of value in a case of concrete conflict between government and central bank. They can assess only long-term independence. Subchapter 3.2 argues that financial market data, in particular yields of long-term government bonds, can help to measure the credibility of a central bank. Subsequently (3.3), an event study will show that the conflict between government and Bundesbank created extreme uncertainty for German financial markets, led to dramatically rising inflationary expectations, and caused significant repercussions in the bond market. This subchapter will also include an outline of the event-study methodology and econometric robustness checks.

Chapter 4 estimates the costs of the credibility loss incurred by the events of 1990. Such an assessment requires the comparison of the development as it took place with the hypothetical development in the absence of the conflict. Such a counterfactual examination is inherently problematic.[11] However, it proves possible to estimate at least a lower limit of costs incurred. This assessment is based on the idea that the government had to grant extremely high interest rates for government bonds issued at that time due to the credibility loss of the Bundesbank.

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[11] Cf. P.D. McClelland, *Causal Explanation and Model Building in History, Economics and the New Economic History* (Ithaca, NY: 1975), pp. 146-68.

2. Qualitative Analysis: Historical events and the cause of conflict

2.1 From the fall of the Berlin Wall until 6th February 1990

The fall of the Berlin Wall on 9th November 1989 took the public by surprise. It took some time before West German politics became aware of the new political opportunities with regard to East Germany and made the first steps towards German reunification.

This began with the so-called "programme of 10 points", announced by the Kohl government on 28th November 1989. It envisaged a gradual rapprochement between the two Germanys, with reunification as the ultimate goal. Concerning the economic sphere, this programme suggested bringing East Germany, step by step, up to West German productivity levels through both market reforms and West German aid. Monetary union was not then envisaged.[12]

This initial concept – economic convergence before monetary union – was called into question by the events of December 1989 and January 1990. The communist government in East Germany proved unwilling or unable to implement the necessary market reforms. The number of East Germans moving to West Germany had initially declined after the fall of the Wall, but the stagnation of reform caused it to rise again. In January 1990, more than 2,000 East Germans per day took advantage of the new opportunity to settle in West Germany and seek work there. This mass exodus led to a dramatic decrease in the effective labour force in East Germany and to considerable pressure on the social security system of West Germany.[13]

The situation deteriorated in the course of January. There emerged proponents of a reversal of what chancellor Kohl had proposed two months before. The core concept was that the rapid introduction of the Deutschmark into East Germany could provide the run-down economy with a reliable institutional

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[12] Grosser, *Das Wagnis der Währungs-, Wirtschafts- und Sozialunion*, p. 149.
[13] Ibid., p. 153.

framework which would boost confidence among Western investors and stop the mass exodus of the labour force.

West German politicians of the social democratic opposition were the first to make this claim.[14] This set in motion a process which is crucial to the understanding of subsequent events. It initiated a four-month long "unrestrained discussion"[15] – as the Bundesbank governor called it angrily in late April 1990 –, during which West German politicians tried to gain the favour of the East German electorate: initially, by offering monetary union, later by offering a favourable conversion rate. After all, the first free elections in the GDR were scheduled for 18th March 1990, and the West German parties wanted to support their newly founded sister parties in East Germany. In addition, monetary union promised to raise their own chances of winning the first elections of a reunified Germany, as the votes of East Germany were likely to determine the final outcome.

The central bank council of the Bundesbank soon realised that this "unrestrained discussion" was gathering momentum. Therefore, several members of the council, among them governor Pöhl and vice-governor Schlesinger, gave interviews in which they opposed the rapid introduction of the Deutschmark into East Germany.[16]

The principal argument of the Bundesbank was that the extremely weak East German currency was a symptom of the run-down East German economy rather than its cause. As vice-governor Schlesinger put it: "It is necessary to pull away the veil of money and to look at the true causes for the East German

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[14] I. Matthäus-Maier, "Signal zum Bleiben. Eine Währungsunion könnte den Umbau der DDR-Wirtschaft beschleunigen", *Die Zeit*, 19th January 1990. Cf. Grosser, *Das Wagnis der Währungs-, Wirtschafts- und Sozialunion*, pp. 153-58.

[15] Speech of Pöhl on the German banking day, 26th April 1990 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 1990 #35, pp. 1-3).

[16] Interview Schlesinger, *Handelsblatt,* 24th January 1990 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 1990 #7, pp. 1-2); interview Pöhl, *Die Zeit,* 26th January 1990 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 1990 #8, pp. 1-4); interview Tietmeyer, *Süddeutsche Zeitung,* 30th January 1990 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 1990 #9, pp. 3-5).

economic weakness."[17] These reasons were believed to be low productivity levels, no free competition, lack of the price mechanism, and no concept of private ownership. A strong and convertible currency could not compensate for low productivity levels and inadequate institutions. It might even ruthlessly expose the true state of the East German economy. For these reasons, the Bundesbank wanted to hold to the initial concept of gradual economic convergence with monetary union as the very last step in the process.

2.2. 6th February 1990: The major clash between national government and Bundesbank

The public crescendo for German Monetary Union could no longer be held back by the Bundesbank once chancellor Kohl had decided to spearhead this movement. He declared to the press on 6th February 1990 that his government would immediately start negotiations with the GDR on the formation of a currency union.[18]

This step was revolutionary, taking into account that the two Germanys were anything but an optimum currency area.[19] After all, most economists doubted that such a currency union would help East Germany.[20] To make matters worse, it was not unlikely that this would do harm to West Germany. Due to the January interviews of central bank council members warning against immediate monetary union, Kohl knew that it was unlikely to win the Bundesbank's consent. However, he did not even inform the Bundesbank about this far-reaching step.

Pöhl met his East German counterpart Kaminsky the same day, 6th February 1990. The talks were intended to generate more information about the

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[17] Interview Schlesinger, *Handelsblatt,* 24th January 1990 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 1990 #7, pp. 1-2).

[18] Grosser, *Das Wagnis der Währungs-, Wirtschafts- und Sozialunion*, pp. 183-84.

[19] R. König, "The D-Mark Exchange Rate Impact", in: *The German Currency Union of 1990: A Critical Assessment*, ed. S.F. Frowen and J. Hölscher (New York: 1997), p. 14.

[20] Grosser, *Das Wagnis der Währungs-, Wirtschafts- und Sozialunion*, pp. 192-96.

financial situation in East Germany. This was considered a precondition for financial aid. As the public had been discussing the issue of monetary union since January, Pöhl and Kaminsky publicly opposed these calls. Both declared a currency union to be economically senseless and out of the question at that time.[21]

As the situation stood on 6th February 1990, chancellor Kohl had made a proposition, which – as will be explained in more detail – exposed the Deutschmark to the risk of dramatic inflation. Kohl was not only unable to achieve the consent of the Bundesbank governor whose job is precisely to safeguard the currency; to make matters worse, this had not even been attempted. This became evident when Pöhl – unknowingly - rejected the chancellor's proposition after the talks with his East German counterpart. The indisputable competence of the Bundesbank had been ignored in such a difficult and far-reaching issue. The conflict between government and Bundesbank became evident on the day of Kohl's proposition.

The conflict began to disturb both the public and financial markets. Pöhl felt the need to appear before the press, trying to explain the situation and to defuse the conflict.[22] Pöhl's press conference on 9th February 1990 was a somewhat unusual step, as the Bundesbank exclusively works with press releases. This step in itself shed negative light on the relationship between central bank and national government. In addition, Pöhl's statement was hardly made to contain concerns over monetary union: Pöhl declared Kohl's proposition a "political decision" for which the government was to bear responsibility. He declared his loyalty to the decision taken by the chancellor. At the same time, he once again made clear that rapid monetary union did not make sense from an economic point of view and could only be justified as preliminary step towards political reunification. Pöhl added that he was very surprised by the fact that he

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[21] Marsh, *The Bundesbank*, p. 209. Grosser, *Das Wagnis der Währungs-, Wirtschafts- und Sozialunion*, p. 184.

[22] Statement of Pöhl at the Federal Press Conference, 9th February 1990 (Deutsche Bundesbank, Press Archive, special folder Pöhl).

had not been informed beforehand. In a later interview, he described the government's behaviour as "unusual and even irritating"[23]. This press conference was likely to deepen the conflict rather than defuse it. Extremely critical interviews given by several central bank council members in the course of February made the relationship between government and Bundesbank even worse.[24]

2.3 Divergent concepts for the appropriate conversion rate

Kohl's proposition had become a fact. Therefore, the conflict shifted during the course of February to the arrangements for German Monetary Union, in particular to the delicate issue of the conversion rate. 6th February 1990 and 2nd May 1990 – when the West and the East German government finally agreed upon a conversion rate – mark the beginning and the end of what Pöhl had called an "unrestrained debate, which gave rise to expectations among the citizens of the GDR which were hardly compatible or not compatible at all with what West Germany could do financially."[25]

The core problem was that there were no convincing economic indicators by which to determine an objectively justified conversion rate.[26] German Monetary Union did not deal with two capitalist economies but with the integration of a centrally planned economy characterised by a non-functioning price mechanism and a large monetary overhang into a capitalist economy. Existing official exchange rates were politically rather than economically determined and overvalued the East Mark. By contrast, the black market exchange rate underestimated the value of the East Mark, for it only reflected the very

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[23] Interview Pöhl, *Der Spiegel,* 26th February 1990 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 1990 #17, pp. 1-4).

[24] Interview Hesse, *Frankfurter Rundschau,* 20th February 1990; interview Kloten, *Stuttgarter Nachrichten,* 9th February 1990; interview Kloten, *Stuttgarter Zeitung,* 27th February 1990.

[25] Speech of Pöhl on the German banking day, 26th April 1990 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 1990 #35, pp. 1-3).

[26] Streit, "German Monetary Union", pp. 651-54.

limited amount of goods East Germans urgently wanted to buy in the West after the fall of the Wall.[27]

Until the beginning of April the Bundesbank did not suggest any conversion rate publicly. Nonetheless, statements and interviews given by members of the central bank council made clear that the Bundesbank considered proposals advanced by government officials overly favourable for the East German currency.

The stance of the government, on the one hand, and the Bundesbank, on the other, can be traced back to two different starting points. The government's main concern was to give East Germans a realistic perspective to stay in East Germany. It thus proved essential to find a conversion rate, which would not enlarge the wage gap between East and West. In addition, East Germans should not be cheated out of their savings. Savings were large in East Germany due to a large monetary overhang, a phenomenon common to most centrally planned economies. Last but not least, the West German government wanted to enhance its sister party's chances in the elections to come (18th March 1990).[28] These motivations led the government to suggest a conversion rate of 1:1, both for stocks and flows. Only very high savings should be converted at a rate of 1:2.[29] Doubts concerning the economic feasibility of the proposed conversion rate were swept away with reference to the extremely successful currency reform in 1948, which had provided West Germany with substantial economic stimulus. This omnipresent comparison completely neglected the fundamental differences between the two currency unions.[30]

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[27] P. Bofinger, "The GMU. Converting Marks into D-Marks", in: *Federal Reserve Bank of St. Louis Review* 7/8 (1990), p. 22. H.-W. Sinn and G. Sinn, *Kaltstart: Volkswirtschaftliche Aspekte der deutschen Vereinigung* (Tübingen: 1991), p. 35. Streit, "German Monetary Union", pp. 651-54.

[28] Marsh, *The Bundesbank*, p. 211:"By paving the way for the expiry of the East Mark, Kohl's decision sounded the death knell for the SPD's hopes of holding political power in the former communist state."

[29] Press release of the West German government, 23th April 1990 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 1990 #34, p. 1).

[30] S. Tober, "Monetary Reform and Monetary Union: A Comparison between 1948 and 1990", in: *The German Currency Union of 1990: A Critical Assessment*, ed. S.F. Frowen and J.

The Bundesbank had a completely different starting point. Its task was to safeguard the German currency. Since there was an empirically well established relationship between the development of prices, on the one hand, and of the money stock (in the form of M3), on the other, the Bundesbank switched in 1974 to safeguarding price stability by money supply targeting.[31] The theoretical foundation of this concept is the quantity theory of money:

$$M * v = P * Y$$

where M is the money stock, v the velocity of circulation, P the price level, and Y the output.

According to this theory, money stock and output of an economy must grow at the same rate if the price level is to remain the same. Notwithstanding that it has recently been questioned whether this monetarist approach was the only principle informing the late Bundesbank's monetary policy[32], interviews and statements by Bundesbank council members make clear that this approach was used when determining an appropriate conversion rate for East Germany.[33] It came to be the Bundesbank's main concern that a money stock growth in excess to the additional East German output would lead to rising prices.

The Bundesbank soon identified a number of difficulties, which made a simple application of the quantity theory impossible. In particular, these concerned estimates of the productivity of the East German economy, which was

Hölscher (New York: 1997), pp. 227-56. G. Pugh, "Economic Reform in Germany: The 1948 Currency and Economic Reforms in Comparison with the 1990 Economic and Monetary Union", in: *The Political Economy of German Unification*, ed. T. Lange and J.R. Shackleton (Providence, RI: 1998), pp. 120-38.
[31] Deutsche Bundesbank, ed., *Die Geldpolitik der Bundesbank* (Frankfurt: 1995), pp. 72, 81.
[32] S. Erkel, *Die Geldpolitik der Deutschen Bundesbank seit Einführung des Geldmengenziels: eine empirische Untersuchung mit Methoden der Zeitreihen- und Kointegrationsanalyse* (Cologne: 1997), p. 109.
[33] Interview Schlesinger, *Finanzen,* 30th April 1990; interview Pöhl, *Die Welt,* 10th April 1990 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 1990 #30, pp. 1-4); interview Hesse, *Frankfurter Rundschau,* 20th February 1990.

a precondition to determine its output. Immediately after the fall of the Wall, productivity levels had been estimated to be approximately 30% to 40% of West German levels, but these had to be corrected downwards permanently.[34] Some calculations only suggested 20% of West German levels; these estimates would have simply meant halving the conversion rate from the Bundesbank's point of view. Moreover, the velocity of circulation was difficult to estimate, given totally different economic and financial structures in East Germany. Furthermore, it was hard to establish the East German money stock, as there were no state balances available.

Some further factors beside the variables of the formula of the quantity theory were also unknown, but required to be taken into consideration; for example, whether the new purchasing power would lead to massive consumption expenditure which would impact on fully used capacities in the West. This would instantly lead to rising prices.

The afore-mentioned arguments carry weight for the conversion of stocks. Concerning flows, in particular wages, the Bundesbank argued the following: that wages should not exceed the productivity level, for this would lead to mass unemployment.[35] As productivity in East Germany was only 30% to 40% of the West German level, a conversion rate needed to be found that would lead East German wages to equal 30% to 40% of those in West Germany after conversion.

Notwithstanding that the arguments put forward by the Bundesbank were economically convincing, they reveal the tragedy of the economic part of German reunification. The Kohl government had suggested the rapid introduction of the Deutschmark into East Germany in order to offer East Germans an incentive to stay. If the "economically correct" wage level of 30% to 40% of the West level were now chosen, the incentive to move to the West would remain. By contrast, if the conversion rate would lead to a higher wage

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[34] Bofinger, "The GMU. Converting Marks into D-Marks", p. 19. Grosser, *Das Wagnis der Währungs-, Wirtschafts- und Sozialunion*, p. 170.
[35] Interview Schlesinger, *Handelsblatt,* 24th January 1990 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 1990 #7, pp. 1-2).

level, there would be a realistic prospect of staying in East Germany only in the short run. In the long run, many East German companies would be forced to lay off workers due to high labour costs. This, in turn, would cause East Germans to move to West Germany. No matter which perspective was adopted, the process of many East Germans leaving their country seemed inevitable after the fall of the Wall – a process which is, albeit on a reduced scale, still taking place more than 10 years after reunification.[36] This conflict was inevitable as long as the migration of the East German labour force to West Germany did not exert downward pressure on wages paid there. Schlesinger had realised this conflict and used it in the afore-mentioned January interview as one of his main arguments against rapid monetary union: "If the borders are open and currency and price level the same, but the productive potential of the companies only 50%, there are two dangers. Either companies in the GDR try to pay as much as companies do here [i.e., in West Germany]. They cannot sustain this for a long period of time and people will start calling for subventions. Alternatively, they do not try to pay as much as companies do in the West. In such a situation, it will be hard to keep the work force in East Germany."[37]

As already mentioned, the Bundesbank did not propose a conversion rate publicly at the outset. It only calculated the appropriate conversion rate according to economic principles. During the month of March the government finally asked the Bundesbank for a proposal concerning the conversion rate. Well aware of the reputation of the Bundesbank with the West German public[38], the government had asked the Bundesbank only for a confidential proposal. This would not limit the government's discretion to agree upon a more favourable conversion rate during the course of the subsequent negotiations with the East German government. The Bundesbank council agreed upon its proposal on 29th March

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[36] H. Giersch and H.-W. Sinn, "Zusammenwachsen heißt zusammen wachsen", *Frankfurter Allgemeine Zeitung*, 29th September 2000.

[37] Interview Schlesinger, *Handelsblatt,* 24th January 1990 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 1990 #7, pp. 1-2).

[38] Berger, "A State within the State?", pp. 17-18. Leaman, *The Bundesbank Myth*, p. 250.

1990, suggesting a conversion rate of 1:2 in order to secure price stability.[39] As we know today from an interview given by Pöhl 10 years after German Monetary Union, this proposal itself was a compromise between what the central bank council considered economically justified and politically acceptable.[40]

At least one member of the central bank council was concerned enough to leak details to the press of the government's asking the Bundesbank for help, but did so anonymously. Using the Bundesbank's reputation, the confidential proposal was leaked[41] (Frankfurter Rundschau, Saturday 31st March 1990), and it entered the public domain.

Once again, the conflict between Bundesbank and government – this time concerning the conversion rate – had become evident. The government's reaction was immediate. Negotiations with the newly elected government in East Germany were soon to begin. Chancellor Kohl realised that he could not conduct these negotiations completely without the Bundesbank. At the same time, he wanted to maintain strict control over the talks. Thus, he recalled Tietmeyer, a former close adviser, from the central bank council and made him chief negotiator with East Germany (Monday 2nd April 1990). This led to the bizarre situation that Tietmeyer had much more power during the course of the negotiations than his chief Pöhl, leading to tension within the Bundesbank council.[42]

It remains difficult to establish whether the dual position of Tietmeyer gave the Bundesbank a stronger say in the subsequent negotiations with East Germany or whether it undermined the Bundesbank's position. In principle, personal independence is considered a prerequisite of central bank independence[43];

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[39] Press release of the Bundesbank, 2nd April 1990 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 1990 #28, pp. 1-2).

[40] Interview Pöhl, *Süddeutsche Zeitung,* 29th June 2000 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 2000 #30, pp. 7-10).

[41] R.-D. Schwarze, "Mark der DDR soll 2:1 getauscht werden. Bundesbankbeschluß. Bis 2000 Mark 1:1", *Frankfurter Rundschau*, 31st March 1990.

[42] Marsh, *The Bundesbank*, p. 215.

[43] Cukierman, *Central Bank Strategy, Credibility, and Independence*, pp. 369-414. Deutsche Bundesbank, ed., *Die Geldpolitik der Bundesbank*, p. 180.

therefore, it cannot have been a surprise that both German[44] and foreign[45] newspapers were highly critical of Tietmeyer's dual function. One thing is certain. The Bundesbank itself did not consider the situation defused: several central bank council members, among them Pöhl and Schlesinger, gave interviews in which they demanded conversion rates compatible with the pursuit of price stability.[46] In the event of conversion rates with potential for inflation, they threatened to raise interest rates dramatically. They made clear that the stability of the Deutschmark was their paramount object.

The West and East German governments agreed upon the conversion rate on 2nd May 1990 and made it public the same day - four days before local elections in East Germany. As outlined before, the West German government had started the negotiations with the proposal of a 1:1 conversion rate.[47] Stocks should be converted 1:2 only above a certain margin. The East German government managed to push up this margin a good deal more in the course of negotiations.[48] Therefore, the conversion rate was even further from what the Bundesbank considered compatible with the pursuit of price stability.

2.4 Further lines of conflict between national government and Bundesbank

The differences of opinion concerning German Monetary Union and, in particular, the conversion rate were at the heart of the conflict between Bundesbank and government. The tensions, however, were also due to two further factors. First, the Bundesbank drew attention early on to the negative

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[44] K.C. Engelen, "Auch Mißverständnisse können schädlich wirken. Tietmeyers Beraterrolle beim Bundeskanzler löst neue Besorgnis über die Unabhängigkeit der Deutschen Bundesbank aus", *Handelsblatt*, 10th April 1990.

[45] D. Marsh, "Kohl under fire for failing to consult Bundesbank over union", *Financial Times*, 24th April 1990. "Union allemande: fronde à la Bundesbank", *Le Figaro*, 29th May 1990.

[46] Interview Pöhl, *Die Welt,* 10th April 1990 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 1990 #30, pp. 1-4); interview Schlesinger, *Finanzen,* 30th April 1990.

[47] Press release of the West German government, 23th April 1990 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 1990 #34, p. 1).

[48] Press release of the West German government, 2nd May 1990 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 1990 #37, pp. 2-3).

long-term economic consequences of German reunification, whilst the government attempted to downplay them. In addition to this, some central bank council members feared that the clash between Bundesbank and government might have negative consequences for European Monetary Union.

2.4.1 The long-run economic consequences of German Monetary Union

The Bundesbank raised its voice not only concerning the appropriate exchange rate. All in all, it can be said that the Bundesbank became more and more an "institution against populism" at a time of elections in East Germany and euphoria over reunification. Several members of the central bank council publicly declared that reunification would cost a great deal and tax increases might become inevitable.[49] These statements annoyed the government, as it wanted the West German public to believe that reunification would not require tax increases. At times this conflict was highly evident; on 26th April 1990, for instance, Waigel, the minister of finance, declared tax increases unnecessary in his speech, whereas Pöhl said exactly the opposite in his ensuing speech at the same event.[50] Due to the high reputation the Bundesbank enjoyed among the public, these statements were likely further to undermine mutual relations.

Fiscal policy is undoubtedly the government's competence. Nonetheless, as expansive fiscal policy entails potential for inflation, the Bundesbank began to worry whether it would be able to safeguard price stability in the long run. To this end, it raised its voice against indirect dangers to monetary policy coming from German Monetary Union and political reunification. For instance, the Bundesbank was afraid that rising unemployment in East Germany, due to the high conversion rate, might give rise to calls for inflation as a sort of "social lubricant". This might erode the social consent necessary to pursue strict monetary policy. Reducing inflation could become difficult also for another

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[49] Interview Pöhl, *Der Spiegel,* 26th February 1990 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 1990 #17, pp. 1-4); interview Kloten, *Stuttgarter Zeitung,* 27th February 1990.
[50] Speech given by Pöhl on the German banking day, 26th April 1990 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 1990 #35, pp. 1-4).

reason; interest rates might rise as a result of the attempt to finance reunification by public debts. Interest rates might reach such a level that the Bundesbank could hardly raise interest rates further, as this would harm investments in East Germany.

The Bundesbank had realised these potential problems early on. It articulated them quite frankly, for instance in an interview given by Pöhl on 26th February 1990.[51] Once again, he gave vent to his annoyance regarding the events of 6th February. He described the behaviour of the government as "unusual and even irritating" – which are strong words for an institution, which was well known for its understatement. The conflict became evident again. This triggered rumours on 1st March 1990 that Pöhl intended to step down. As we know today, Pöhl indeed wanted to step down, but did not, so as not to exacerbate an already tense situation.[52] Notwithstanding that these rumours were immediately denied by the Bundesbank, financial markets reacted nervously to the news. The very notion of central bank independence seemed to be at stake.

2.4.2 Consequences for the negotiations on European Monetary Union

The third line of conflict was subtler. Nonetheless, it is no less interesting. Hesse, the central bank governor of Lower Saxony, one of the German *Länder*, gave a lecture at the respected Kiel Institute for World Economics on 14th May 1990. This lecture, carrying the title "Two Currency Unions: Problems and Perspectives" caused a sensation, both in the German and the foreign press. Referring to German Monetary Union, Hesse said:

> "It is hard to find a convincing argument against the opinion that has recently arisen abroad, that the Bundesbank was deprived of its leading position in monetary policy. The Bundesbank was expected to support the general economic policy [of the government], notwith-

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[51] Interview Pöhl, *Der Spiegel,* 26th February 1990 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 1990 #17, pp. 1-4).
[52] Marsh, *The Bundesbank*, p. 210.

standing that it had made clear that it was unable to do so without neglecting its task, i.e. to safeguard the value of the currency."[53]

Of particular note in Hesse's speech was that he linked up the conflict between the Bundesbank and German government with a future European Monetary Union. According to Hesse, German monetary policy was characterised by two principles which Germany should make a precondition of entering European Monetary Union: the independence of the central bank and the exclusive objective of the central bank to safeguard price stability. For Hesse, both principles had been harmed by German Monetary Union. Thus, he raised the issue of whether this would limit the persuasive power of the German government in the negotiations to come.

Hesse's reference to European Monetary Union is instructive and demonstrates a further dimension to the conflict between government and Bundesbank. The concept of European Monetary Union had become relevant again after the Delors Report in 1989.[54] Following a decision at the European summit in December 1989, negotiations had begun in early 1990, i.e. at the same time as the negotiations on German Monetary Union. These negotiations led to the conference of Maastricht in December 1991, at which European Monetary Union was agreed. In the course of these negotiations, it was the German position that a future European central bank had to be independent of the European Commission and the member states, and that the central bank's primary objective was to safeguard price stability.

With hindsight, it can be said that Hesse's concerns did not materialise: the European Central Bank, as established by the treaty of Maastricht, is independent both from the European Commission and the member states.[55] The main task of

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[53] Speech given by Hesse at the Kiel Institute for World Economics, 14th May 1990 (Deutsche Bundesbank, Press Archive, special folder Hesse).

[54] D. Gros and N. Thygesen, *European Monetary Integration*, 2nd ed. (New York: 1998), p. 401.

[55] Treaty establishing the European Community, 25th March 1957 (as in force in 2001), article 108: „When exercising the powers and carrying out the tasks and duties conferred upon them by this Treaty and the Statute of the ESCB, neither the ECB, nor a national central bank, nor any

the European Central Bank is to safeguard price stability.[56] However, as negotiations were taking place simultaneously, Hesse's concern that Germany would lose persuasive power was justified. Far from being as explicit as Hesse, the interrelation between European and German Monetary Union had also been formulated by Pöhl and other members of the central bank council.[57]

Hesse's lecture, and the news coverage of it, demonstrated a further aspect of the conflict. It threatened to take on a European dimension. Pöhl could not tolerate this, in particular as he tried to limit the damage of the conflict after the governments of the two Germanys had agreed upon a conversion rate. Further discussion could only damage the Bundesbank's credibility. These concerns were strongly justified, as the number of newspaper articles in May and June on the independence of the Bundesbank demonstrates.[58]

Therefore, Pöhl forced Hesse to withdraw the speech from circulation and not to publish it.[59] In addition to this, the central bank council – including Hesse – passed a "good-weather-communiqué" on 31st May 1990:

> "The Bundesbank has participated intensively in the negotiations with the GDR concerning German Monetary Union. The Bundesbank governor took part in all important deliberations held at

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member of their decision-making bodies shall seek or take instructions from Community institutions or bodies, from any government of a Member State or from any other body. The Community institutions and bodies and the governments of the Member States undertake to respect this principle and not to seek to influence the members of the decision-making bodies of the ECB or of the national central banks in the performance of their tasks."

[56] Treaty establishing the European Community, 25th March 1957 (as in force in 2001), article 105: „The primary objective of the ESCB shall be to maintain price stability. Without prejudice to the objective of price stability, the ESCB shall support the general economic policies in the Community with a view to contributing to the achievement of the objectives of the Community as laid down in Article 2."

[57] Interview Pöhl, *Die Zeit,* 26th January 1990 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 1990 #8, pp. 1-4); interview Tietmeyer, *Süddeutsche Zeitung,* 30th January 1990 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 1990 #9, pp. 3-5).

[58] K.C. Engelen, "Bundesbank in der Krise. Den Nerv getroffen", *Handelsblatt*, 30th May 1990. J. Jeske, "Herausforderungen für die Bundesbank", *Frankfurter Allgemeine Zeitung*, 28th May 1990. "Union allemande: fronde à la Bundesbank", *Le Figaro,* 29th May 1990. D. Marsh, "Kohl under fire for failing to consult Bundesbank over union", *Financial Times,* 24th April 1990.

[59] "Niedersächsischer Rückzieher: Die "nicht gehaltene" Rede des Zentralbankratsmitglieds Helmut Hesse", *Frankfurter Rundschau*, 8th June 1990.

ministerial and cabinet's level and had the opportunity to present the Bundesbank's point of view."[60]

This statement is correct and irritating at the same time. Kohl's failure to inform Pöhl before 6th February 1990 was the bone of contention. As Kohl had taken the decision on German Monetary Union together with some close advisers, Pöhl's statement that the Bundesbank governor took part in all important deliberations "held at ministerial and cabinet's level" is formally correct. It is, furthermore, somewhat vague to state that the Bundesbank had the opportunity to present its point of view. This neglects the crucial point as to whether the Bundesbank's point of view was taken into consideration when determining the conversion rate.

This statement concluded four turbulent months between government and Bundesbank. Subsequently, tensions calmed, as Pöhl had made clear with his press release from 31st May 1990 that he would not tolerate any further discussion on the issue.

2.5 The cause of conflict: independence versus credibility

The clash between Bundesbank and government centred principally on the conversion rate as part of German Monetary Union. Concerns over long-term economic consequences of German Monetary Union and concerns over future European Monetary Union were subsidiary conflicts. Having outlined the chronology, the principal question is what these events meant to the independence of the Bundesbank.

The starting point is the Law on the Bundesbank, which establishes the independence of the Bundesbank and defines its task and its power. The task of the Bundesbank is to safeguard price stability (§3).[61] The instruments of

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[60] Press release of the Bundesbank, 31st May 1990 (Deutsche Bundesbank, ed., *Auszüge aus Presseartikeln*, 1990 #45, pp. 2-3).
[61] §3 of the Law on the Bundesbank (as in force in 1990): „Die Deutsche Bundesbank regelt mit Hilfe der währungspolitischen Befugnisse, die ihr nach diesem Gesetz zustehen, den Geldumlauf und die Kreditversorgung der Wirtschaft mit dem Ziel, die Währung zu sichern,

determining reserve requirements, setting interest rates, and conducting open market operations – the classic instruments of an independent central bank – are available to the German central bank to enable it to fulfil this task (§§15-16). The Bundesbank is not subject to governmental directives in the use of these instruments.[62] Notwithstanding its independence, the Bundesbank is expected to support the general economic policy of the government as far as this general support does not conflict with the Bundesbank's task of safeguarding price stability.

In reality, however, handing over monetary policy to an independent central bank is not sufficient to safeguard price stability. Price stability can also be severely affected by fiscal and currency policy. These fields are under governmental control. As decisions in these fields, in particular in the area of currency policy, may make the Bundesbank's task more difficult, the Law on the Bundesbank provides for mutual consultations. §13 section 3 says: "The government ought to invite the Bundesbank governor to take part in deliberations on currency policy issues of importance."[63] Consultations of this kind used to be the procedure for realignments within the European Monetary System.

This regulation is relevant in our context: the Bundesbank did not have the right to conclude the treaty on monetary union with the GDR. Nonetheless, the government ought to have asked for the Bundesbank's opinion concerning German Monetary Union. §13 section 3, however, does not oblige the government to consult the Bundesbank. It only says "*ought to* invite the Bundesbank governor" (*sollen* instead of *müssen*). From a legal point of view, it cannot be argued that the government violated the Bundesbank's independence.

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und sorgt für die bankmäßige Abwicklung des Zahlungsverkehrs im Inland und mit dem Ausland."

[62] §12 of the Law on the Bundesbank (as in force in 1990): „Die Deutsche Bundesbank ist verpflichtet, unter Wahrung ihrer Aufgabe die allgemeine Wirtschaftspolitik der Bundesregierung zu unterstützen. Sie ist bei der Ausübung der Befugnisse, die ihr nach diesem Gesetz zustehen, von Weisungen der Bundesregierung unabhängig."

[63] §13 section 3 of the Law on the Bundesbank (as in force in 1990): „Die Bundesregierung soll den Präsidenten der Deutschen Bundesbank zu ihren Beratungen über Angelegenheiten von währungspolitischer Bedeutung zuziehen."

Nonetheless, it is questionable whether the 1990 conflict can be encompassed just by the legal category of independence. In the following, we will argue that credibility rather than independence was at stake in 1990.

The distinction between independence of the central bank, on the one hand, and credibility of monetary policy, on the other, goes back to the economic rationale underlying central bank independence. Any government is confronted with a conflict of aims. Governments disregard price stability if they want to use inflation to reduce unemployment, to reduce government debt, or to finance expenditure, merely the three most important motivations for governments to inflate.[64] The result is that economic agents will adapt to the potential for inflation. They will enter into contracts, which take expected inflation into account.[65] The delegation of monetary policy to an independent central bank with the task of safeguarding price stability is considered to be the best means of avoiding such a conflict of aims. Indeed, central bank independence has proved to be sufficient to safeguard price stability *under normal conditions*.[66]

Normal conditions, however, were not present in 1990 when the enlargement of the West German currency area was at stake. Potential for inflation did not come from monetary policy in the narrow sense. But it did come from the conversion rate, which is also to be considered part of monetary policy (in its wider sense). Economic agents do not concern themselves with from where, precisely, the potential for inflation comes. They acknowledge it and adapt to it. Therefore, the credibility of German monetary policy was affected in 1990, notwithstanding that the independence of the Bundesbank had not been violated. This is the crucial point that differentiates the 1990 conflict from

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[64] Cukierman, *Central Bank Strategy, Credibility, and Independence*, p. 3.

[65] F.E. Kydland and E.C. Prescott, "Rules Rather than Discretion: The Inconsistency of Optimal Plans", in: *Journal of Political Economy* 85 (1977), pp. 473-91. J.R. Barro and D.B. Gordon, "Rules, Discretion and Reputation in a Model of Monetary Policy", in: *Journal of Monetary Economics* 12 (1983), pp. 101-21.

[66] S.C.W. Eijffinger, ed., *Independent Central Banks and Economic Performance* (Elgar: 1997), p. XI. Cf. K. Rogoff, "The Optimal Degree of Commitment to an Intermediate Monetary Target", in: *Quarterly Journal of Economics* 100 (1985), pp. 1169-89. C.E. Walsh, "Optimal Contracts for Central Bankers", in: *American Economic Review* 85 (1995), pp. 150-67.

previous conflicts between government and Bundesbank. "Routine" issues of monetary policy were at stake in the earlier clashes. Politicians were annoyed at interest rates set by the Bundesbank. By contrast, German Monetary Union led to an expansion of the German money stock of approximately 15%.[67]

Thus, the relationship between independence and credibility can be described as follows: central bank independence is only a means to an end.[68] This end is the credibility of monetary policy. Central bank independence is a necessary, but not a sufficient precondition for the desired credibility of monetary policy.

We have used the notion "credibility of monetary policy" and have not used the notion "credibility of the central bank", as we consider this choice of words more appropriate. In accordance with the theory of the time inconsistency of optimal plans[69], the core concern is the credibility problem of monetary policy if monetary policy is exerted by the government. An independent central bank is the best means to overcome this. Thus, handing over monetary policy to an independent central bank is intended to make monetary policy more credible; this delegation does not take place to make the central bank credible.

In some instances, this differentiation is more than semantics. This is evident when turning to the second conflict of 1990, i.e. the long-term economic consequences of German Monetary Union and German reunification. The Bundesbank feared that calls for inflation as a kind of "social lubricant" might resurface due to increasing unemployment in East Germany and that expansive fiscal policy might impede strict monetary policy. The Bundesbank's efforts to safeguard price stability might be counteracted and condemned to fail. In such a case, economic agents might consider the Bundesbank's efforts to safeguard price stability credible. Nonetheless, monetary policy (as a whole) would no longer be credible.

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[67] Deutsche Bundesbank, ed., *Die Geldpolitik der Bundesbank*, p. 86.
[68] Cf. K. Blackburn and M. Christensen, "Monetary Policy and Policy Credibility: Theories and Evidence", in: *Journal of Economic Literature* 27 (1989), pp. 1-45.
[69] Cf. footnote 65.

Therefore, the second conflict can also be captured by the dichotomy between independence and credibility. The Bundesbank expressed concerns over the long-term credibility of German monetary policy and, in turn, tried to prevent anything that might counteract price stability. Conversely, the government, considering fiscal policy its own area of responsibility, could not understand why the Bundesbank raised concerns over this issue.

Concerns over long-term price stability were also the driving force behind Hesse's critical lecture on European Monetary Union. Hesse was afraid that the concept of central bank independence would lose out to solutions with more potential for inflation in the negotiations on European Monetary Union. His main argument was that the German government, which had traditionally advocated the independence of a future European Central Bank, was losing its powers of persuasion through its actions over the national central bank. A dependent central bank in Europe would presumably lead to further inflation.

We conclude that the 1990 conflict between Bundesbank and West German government is best characterised by the difference between independence and credibility. The government did not see any problem as long as legal independence was respected. By contrast, the Bundesbank aimed at credibility of German monetary policy and, in turn, did not want to accept excessive monetary expansion. Therefore, the events of 1990 have negatively affected the credibility of German monetary policy, notwithstanding that the government did not break the Law on the Bundesbank.

3. Quantitative Analysis: Measuring lost credibility

3.1 The irrelevance of conventional measurements of central bank independence to the problem in question

The recent emphasis in economics on the importance of central bank independence (CBI) has led to various attempts to measure the degree of independence a central bank possesses with regard to its government. The existing measurements of CBI focus on legal aspects of CBI.[70] They consider the legal status of a central bank as defined in the central bank charter a good proxy for CBI.

However, these conventional indices are of little use for the present purpose. Within the assumption of strict law enforcement, these indices might be a good proxy for CBI over long periods of time. By contrast, they are not relevant when it comes to concrete conflicts between a government and a central bank: in such a situation, the government will simply exert influence on the central bank, but will refrain from changing the CB charter as this would make the conflict even more public. This has led scholars studying historical clashes between central banks and their governments to a sceptical position towards conventional indicators.[71] In our case, government officials were likely to be annoyed with the independent and self-confident course of the Bundesbank, but no one – at least publicly – thought of changing legislation relating to the Bundesbank.

Such a change in legal status would not have even been necessary, since independence itself was not at stake in 1990. According to the conclusions of the

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[70] A. Alesina and L. Summers, "Central Bank Independence and Macroeconomic Performance: Some Comparative Evidence", in: *Journal of Money, Credit, and Banking* 25 (1993), pp. 151-62. Cukierman, *Central Bank Strategy, Credibility, and Independence*. A. Cukierman, S.B. Webb, and B. Neyapti, "Measuring the Independence of Central Banks and its Effect on Policy Outcomes", in: *World Bank Economic Review* 6 (1992), pp. 353-98. V. Grilli, D. Masciandaro, and G. Tabellini, "Political and Monetary Institutions and Public Finance Policies in the Industrial Countries", in: *Economic Policy* 13 (1991), pp. 341-92.
[71] Berger, "A State within the State?", p. 18.

previous chapter, any measurement has to capture credibility rather than independence. Credibility is a more encompassing concept than independence. Therefore, any measurement of credibility must also capture factors that are crucial in determining a central bank's position towards the government but escape legal indicators. For example, a good track record of monetary discipline[72] and of handling external shocks effectively will enhance the reputation of the central bank and make it more 'untouchable' in the eyes of the government. This holds for instance for the Bundesbank, which had not only achieved very low inflation rates but also successfully handled crises, such as the 1987 stock market crash.[73] Moreover, the historical experience of hyperinflation may make a population especially inflation averse and, in turn, place limitations on government attempts to determine the central bank's monetary policy.

These examples illustrate the manner in which different factors go into determining a central bank's credibility. This might easily cast doubt on the possibility of ever finding or constructing such an indicator.

3.2 Measuring inflationary expectations

However, such "processing" of all the relevant information can be located in financial markets. According to the efficient market hypothesis[74], financial markets take all relevant information into account to determine the value of financial assets. As financial markets are assumed to be efficient, they are able to determine the appropriate value of the financial assets in question. Therefore, it is essential to look for financial assets – and the corresponding markets – which can tell us something about the credibility of the Bundesbank and concerns of economic agents over future monetary policy.

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[72] Grilli, Masciandaro, and Tabellini, "Political and Monetary Institutions and Public Finance Policies in the Industrial Countries", p. 366.

[73] D. Begg, "The Design of EMU", in: *IMF. Staff Studies for the World Economic Outlook* (1997), p. 115.

[74] J.Y. Campbell, A.W. Lo, and A.C. MacKinlay, *The Econometrics of Financial Markets* (Princeton: 1997), pp. 20-22.

The stock market is of little value. It mainly reflects real economic developments and real economic expectations. Whether inflationary monetary policy – as it was expected in 1990 – has significant real economic consequences at all, is heavily disputed. Therefore, conflicts between government and central bank are unlikely to show up at the stock market. Indeed, the German stock market in 1990 was mainly guided by positive expectations based on German reunification and reconstruction needs in East Germany.[75] Stock market indices reached unprecedented heights. It follows that the stock market is not of interest in this paper. The foreign exchange and bond markets are more likely to be of interest in our context.

3.2.1 The foreign exchange market

The exchange rate has also been described as a kind of international assessment.[76] A currency, which is exposed to inflation, is likely to come under pressure to devalue; e.g., this interrelation between high inflation and devaluation was the driving force behind the numerous realignments of the Italian Lira in the European Monetary System (EMS). Beside real economic factors, the exchange rate also reflects foreign confidence in the national currency. This holds in particular for currencies such as the deutschmark, which used to be, after the US-dollar, and together with the pound, one of the world's reserve currencies.

Figure 1 shows the exchange rates of four major currencies in the four weeks following the first conflict between Bundesbank and government. All numbers are relative exchange rates, referring to 5th February 1990. There were no major trends before this date. The value of the Deutschmark increased during the week following the conflict. This is exactly the opposite of what one would normally expect. Therefore, it is tempting to argue that factors which are not relevant in our context had a much stronger influence on the exchange-rate development than concerns over the long-term stability of the Deutschmark.

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[75] Deutsche Bundesbank, *Monthly Report*, June 1990, pp. 8, 40; ibid., February 1990, p. 18; ibid., September 1990, p. 20; Bank of England, *Quarterly Bulletin*, May 1990, pp. 181, 195.
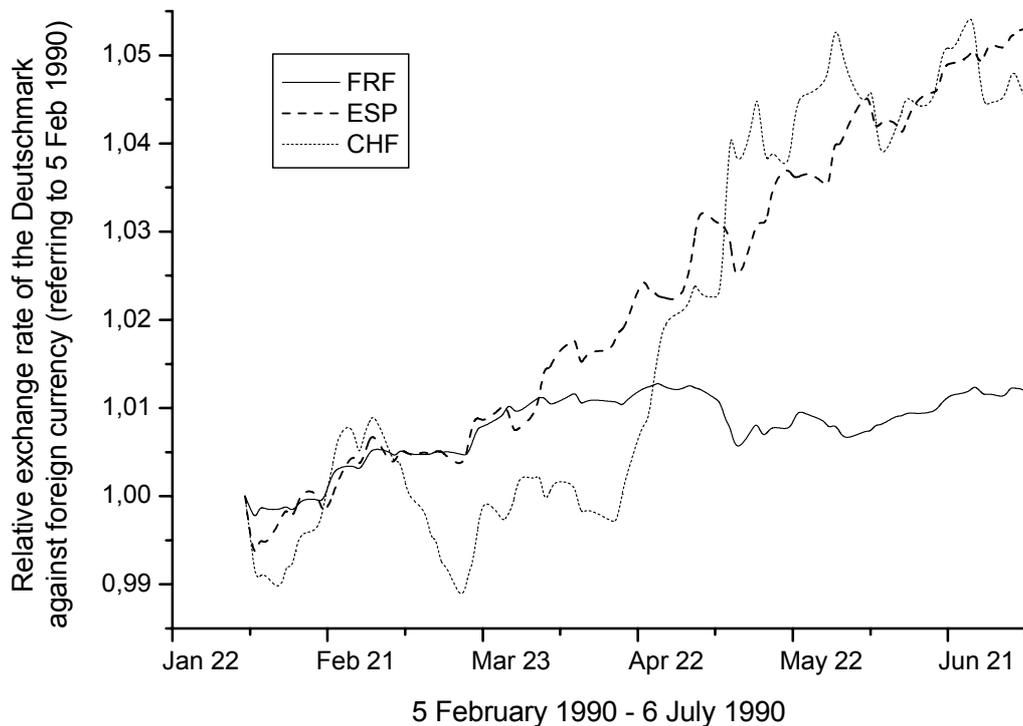[76] König, "The D-Mark Exchange Rate Impact", p. 15.
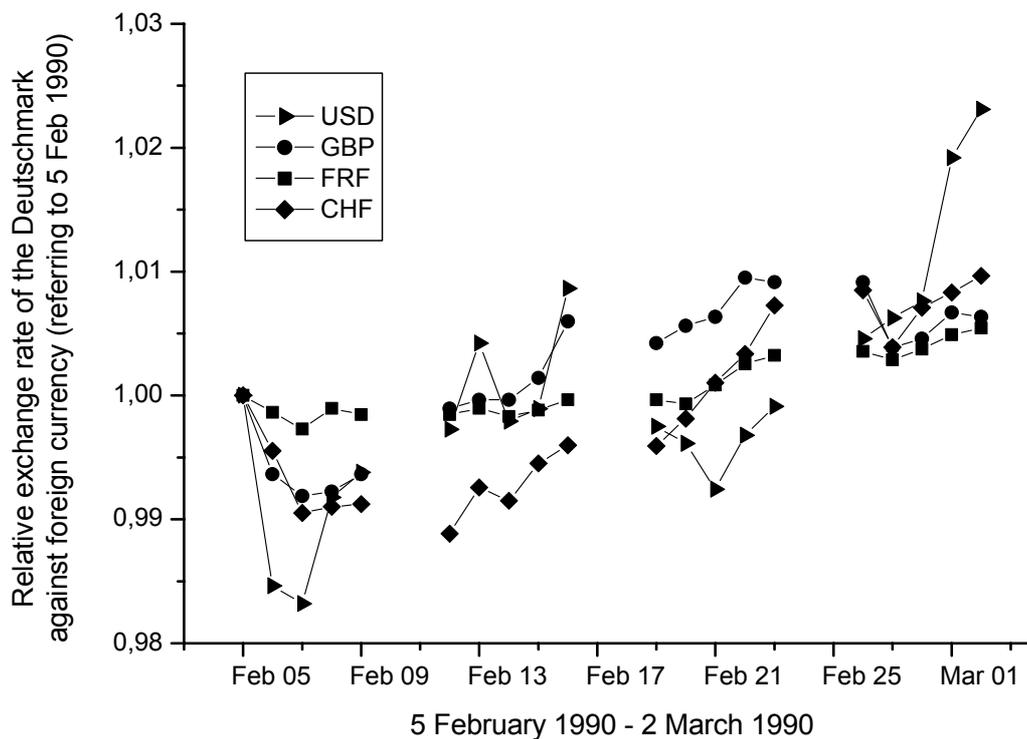
Figure 1: **Relative exchange rates of the Deutschmark against four major currencies (referring to 5 February 1990), 5 February 1990 – 2 March 1990.**

Source: Time series of the Bundesbank (unpublished; internal classification: WT5005, WT5009, WT5012, WT5016)

When referring to the period from February to July 1990, it is possible to say that the Deutschmark depreciated with regard to the Swiss franc and – within the European Monetary System – the Spanish peseta and the French franc (figure 2). This depreciation even required interventions on behalf of the EMS central banks.[77] However, as figure 2 shows, it is not possible to bring the data into congruence with the key events of the qualitative analysis. It is only possible to detect a trend.

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[77] Bank of England, *Quarterly Bulletin,* May 1990, p. 159; ibid., August 1990, p. 344.

Figure 2: **Relative exchange rates of the Deutschmark against the French franc, the Spanish peseta, and the Swiss franc (referring to 5 February 1990), 5 February 1990 – 6 July 1990.**

Source: Time series of the Bundesbank (unpublished; internal classification: WT5006, WT5012, WT5016)

Such a trend can only be ascertained with regard to continental European currencies. It is not possible concerning the US-dollar and the pound. This is probably due to the fact that 1990 was a very eventful year on a global scale, including global crises. In our context, the Lithuanian crisis of March 1990 is of some importance. This crisis created disturbances in the foreign exchange-markets, leading to reallocations of world currency reserves.[78]

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[78] Bank of England, *Quarterly Bulletin*, May 1990, p. 196.

3.2.2 The bond market

The bond market is more promising. Whilst the foreign exchange market reflects inflationary dangers only very indirectly, the bond market is a good deal closer. If inflationary expectations increase due to a decline in central bank credibility, economic agents expect higher nominal interest rates to compensate for expected inflation. This is because they are aiming at a constant real interest rate. This phenomenon has become known as the Fisher effect. To put it another way: the term structure can tell us something about inflationary expectations of economic agents.[79] These inflationary expectations, in turn, reveal the degree of credibility a central bank has in the eyes of economic agents.[80]

The main problem of this approach is that changes in yields are not necessarily due to changes in inflationary expectations.[81] Yields are the sum of four components about which they reveal information: (1) real interest rate, (2) inflationary expectations, (3) expectations about the exchange rates, and (4) the default risk.

To begin with (3) and (4): the default risk for German government bonds is likely to be quite low and can be neglected. Concerning exchange rates, forward exchange rate data for the year 1990 indicate that there were no expectations (yet) about realignments within the European Monetary System.[82] Thus, it also seems justified to disregard expectations about exchange rates.

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[79] F. Mishkin, "The Information in the Longer-Maturity Term Structure about Future Inflation", in: *Quarterly Journal of Economics* 105 (1990), pp. 815-21. F. Mishkin, "What Does the Term Structure Tell Us about Future Inflation?" in: *Journal of Monetary Economics* 25 (1990), pp. 77-95. F. Modigliani and R. Shiller, "Inflation, Rational Expectations, and the Term Structure of Interest Rates", in: *Economica* 40 (1973), pp. 12-43. E. Fama, "Term-Structure Forecasts of Interest Rates, Inflation, and Real Returns", in: *Journal of Monetary Economics* 25 (1990), pp. 59-76. E. Fama, "Short-Term Interest Rates as Predictors of Inflation", in: *American Economic Review* 65 (1975), pp. 269-82.

[80] L.E.O. Svensson, *Estimating and Interpreting Forward Interest Rates: Sweden 1992-4*, CEPR Discussion Paper 1051 (London: 1994). L.E.O. Svensson, "Monetary Policy with Flexible Exchange Rates and Forward Interest Rates as Indicators", in: *Banque de France. Cahiers économiques et monétaires* 43 (1994), pp. 305-32.

[81] P. Söderlind, *Monetary Policy and the Fisher Effect*, CEPR Discussion Paper 1610 (London: 1997).

[82] P. DeGrauwe, *Economics of Monetary Union*, 4th ed. (Oxford: 2000), pp. 118-24.

There is still the need to differentiate between (1) and (2). This holds at least for Germany, where there were no markets for indexed bonds – as in the UK[83] - in 1990. However, further analysis allows the estimation of inflationary expectations and identifies them as the driving force behind rising yields. Therefore, in the following we will work with yields of German government bonds.

Figure 3 shows yields for German bonds from 4th August 1989 to 3rd August 1990 for different remaining terms. Yields show – as expected – a similar pattern for different remaining terms. Therefore, there is no difference in which remaining term is studied. The Bundesbank did not change bank base rates during this period.[84] Changing yields thus only reflect market activities. Therefore, it would even be possible to look at a very short remaining term for the purposes of examining the degree to which the Bundesbank lost credibility. Nonetheless, as our interest focuses on long-term inflationary expectations, German government bonds with a remaining term of 10 years will be used in the following analysis.

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[83] Svensson, *Estimating and Interpreting Forward Interest Rates: Sweden 1992-4*, p. 11.
[84] Deutsche Bundesbank, *Monthly Report*, June 1990, p. 8.
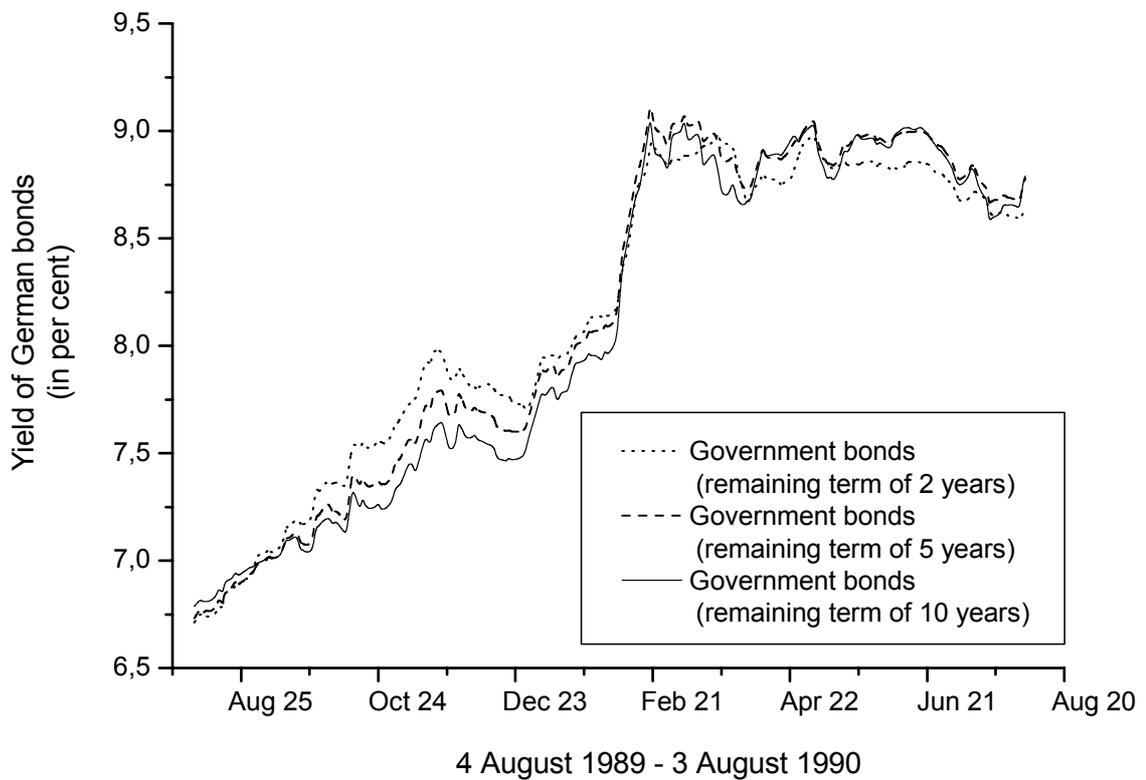
Figure 3: **German government bond yields for different remaining terms, 4 August 1989 – 3 August 1990.**

Source: Time series of the Bundesbank (unpublished; internal classification: WT3039, WT3045, WT3055)

3.3 The conduct of an event-study

3.3.1 The concept of an event-study

The core concept of an event-study is that spontaneously occurring events of economic importance will be reflected in asset prices in financial markets after a very short period of time. This is the result of the efficient market hypothesis, which states that markets are efficient in the sense that economic agents quickly

take notice of changing economic conditions – both on the macroeconomic and on the firm levels –, which will lead them to adjust asset prices if necessary.

An event-study attempts to ascertain statistically whether the changes in valuation after the announcement of the event in question are within a regular range; alternatively, the changes in valuation might be of such a large scale that they cannot be explained by previous fluctuation, but only by the event itself.[85]

Event studies have recently become very popular in economic history. This is due to the fact that they open up a way to prove econometrically the predictions of New Institutional Economics that institutions matter for economic performance.[86] The central concept of these studies is to examine financial market data in times of institutional crisis.[87] This paper follows this line of research and attempts to evaluate what economic agents thought about the credibility of the Bundesbank in 1990.

Event definition, estimation window, event window

First, the event needs to be defined and dates determined. In this case, the event is primarily the first conflict between the West German government and the Bundesbank. This dates from 6th February 1990 in the afternoon, but before the closure of the German bond market. The later events will subsequently be dealt with in the same manner. Table 1 presents the key historical episodes from the qualitative analyses, which are likely to constitute an event.

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[85] Campbell, Lo, and MacKinlay, *The Econometrics of Financial Markets*, pp. 149-50. J.J. Binder, "The Event Study Methodology Since 1969", in: *Review of Quantitative Finance and Accounting* 11 (1998), pp. 111-37.

[86] D.C. North and B.R. Weingast, "Symposium: High Politics and Low Finance. Introduction: Institutional Analysis and Economic History", in: *Journal of Economic History* 60 (2000), pp. 414-17.

[87] B.S. Frey and M. Kucher, "History as Reflected in Capital Markets: The Case of World War II", in: *Journal of Economic History* 60 (2000), pp. 468-96. K.L. Willard, T.W. Guinnane, and H.S. Rosen, "Turning-Points in the Civil War: Views from the Greenback Market", in: *American Economic Review* 86 (1996), pp. 1001-18. J. Wells and D. Wills, "Revolution, Restoration, and Debt Repudiation: The Jacobite Threat to England's Institutions and Economic Growth", in: *Journal of Economic History* 60 (2000), pp. 418-41.

The essence of the event-study is the comparison of bond yields in a certain period of time before the 6th February with the yields immediately after the conflict became known to economic agents. The chosen period of time before the 6th February is labelled the estimation window, the period thereafter the event window. Two core principles define the establishment of the two windows: the estimation window should consist of yields of as many trading days as possible before 6th February. The rationale behind this is to determine the average variation as precisely as possible and to describe a previous trend if existent. In this paper, the six months before the conflict have been chosen (4th August 1989 – 5th February 1990). In comparison with other event studies, this represents a somewhat extensive estimation window (127 trading days).[88]

In contrast to the estimation window, the event window should comprise only a small number of days, if possible only the day of the event itself. Choosing a very short event window serves the purpose of eliminating other events and their potential impact on bond yields as far as possible. That is, the aim is to enable a comparison of the yields before and after the event *ceteris paribus*.

Table 1

Major events during conflict between government and Bundesbank

Event	Date at which news reaches the market
Kohl proposes German Monetary Union without informing the Bundesbank	6th February 1990
Rumours that Pöhl would step down	1st March 1990
Bundesbank proposal concerning the conversion rate leaks to the press Government recalls Tietmeyer from the Bundesbank	2nd April 1990
West and East German government announce the conversion rate	2nd May 1990

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[88] Campbell, Lo, and MacKinlay, *The Econometrics of Financial Markets*, p. 152.

<u>Abnormal yields and test of significance</u>

After having chosen the estimation and event windows, the yields in the event-window are compared with the hypothetical yields that one would expect in the absence of the event. In this process, the hypothetical yields are estimated as a continuation of the previous trend in the estimation window.

Subsequently it will be ascertained whether the abnormal yields – i.e. the difference between the yields as they occurred and the yields as they have been estimated on the grounds of the previous trend – are statistically significant. This entails establishing the probability with which the abnormal yields cannot be interpreted as a continuation of the previous trend and, in turn, can only be explained by the event in question.

It is evident that the choice of model to describe the hypothetical development in the event window is of great importance. There is, essentially, no "ideal" model; that selected must be the one best suited to predict the hypothetical development.

Therefore, it is necessary to take the yields in the estimation window into account in order to choose a well-suited model (figure 4). A phase of rising yields may be observed. The yield curve is characterised by a trend. This trend is only interrupted for a short period of time after the fall of the Wall (9th November 1989), but the yield curve moves back to its trend after a technical adjustment at the end of year. The trend is characterised by the regression line.

The results of our regression (table 2) suggest a two-step approach. The results obtained, in particular the high R^2 (0.9533) and the high t-ratios (515.74 and 50.52 respectively), are good enough to proceed directly with prediction based on the linear single regression model (3.3.2.1). This is one of the standard OLS inferential procedures which allows us to forecast the development of the yield curve on 6th February 1990 and the following days given the previous trend. Our result will be that the actual development of yields following that day cannot be interpreted as a continuation of the previous trend and, in turn, can only be explained by the event in question.
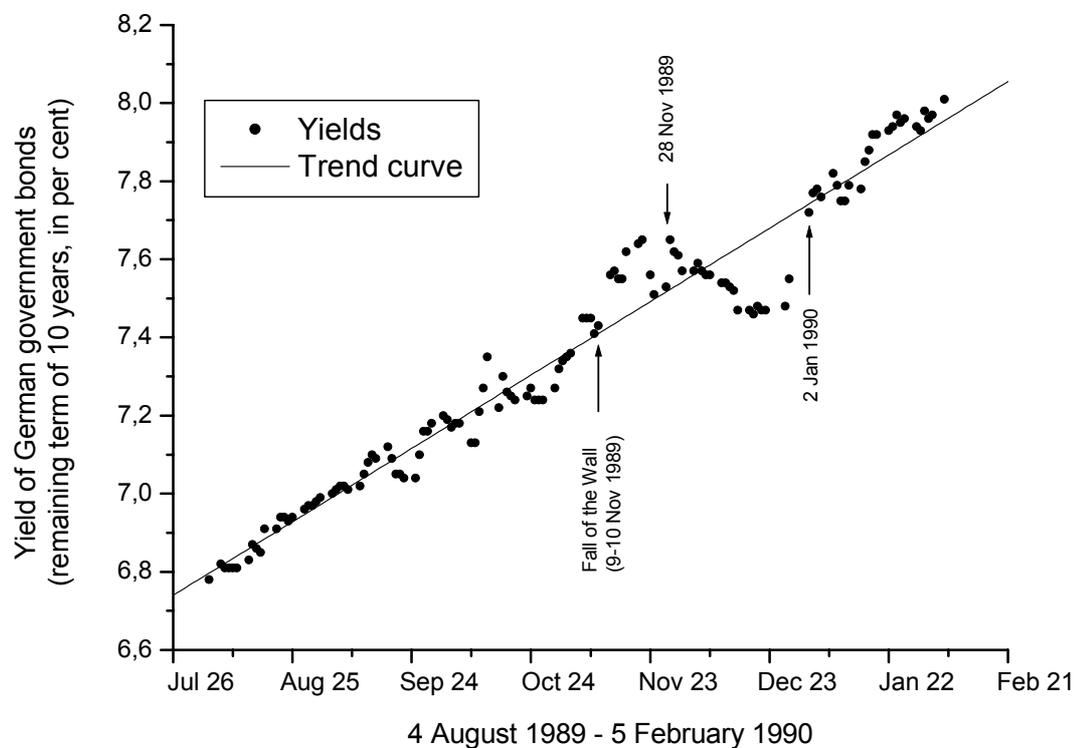
Figure 4: **Yields of German government bonds (remaining term of 10 years), 4 August 1989 – 5 February 1990.**

Source: Time series of the Bundesbank (unpublished; internal classification: WT3055)

Table 2

Regression results: German government bond yields,

4 August 1989 to 5 February 1990

(see figure 4)

Parameter	Coefficient	Standard error	t-value
α (intercept)	6.789473	0.013164	515.7430
β (time trend)	0.009125	0.000181	50.52271
N	R^2	Durbin-Watson-value	F-value
127	0.953315	0.267180	2552.544

Least squares estimation of the equation $Y_t = \alpha + \beta t + u_t$, where t represents trading days and Y_t the yield on day t (t=1 corresponds to 4 August 1989 and t=127 corresponds to 5 February 1990); u_t is assumed IID$(0, \sigma^2)$.

Subsequently (3.3.2.2) we attempt to establish whether this result still holds when applying more sophisticated econometric techniques. The robustness checks will first lead us to interpret our time series as an autoregressive process subject to a time trend (deterministic trend); alternatively, we will interpret our time series as subject to a stochastic trend. Prediction based on either interpretation will not change our initial finding that 6th February 1990 constitutes an event.

3.3.2 6th February 1990

Determination of prediction intervals within the framework of the linear single regression.

The determination of prediction intervals within the framework of the linear single regression is one of the most widely used OLS standard inferential procedures. The basic idea is as follows: it is not possible to say that the hypothetical value for 6th February must be on the regression line itself. This would deny the fact that not only the trend, but also a certain variation around the

trend determines the yield, as is evident from figure 4. However, it is possible to use both kind of information – i.e. the estimated trend and the estimated variation from the estimation window – to ascertain a prediction interval, in which the hypothetical values of the event will be with a probability $1 - \delta$. If the real values of the event window are found to be outside the predicted bands, it can be said *e contrario* that the surprise event has had a significant impact on the yields with a probability of $1 - \delta$. A more detailed description and the exact formulae can be found in appendix 1.

Figure 5 shows the results of the event study for 6th February 1990. Most values within the half-year estimation window are found well within the prediction bands. By contrast, the value for 6th February deviates from the previous trend and is found off the 95%-predictions bands. The upper bound of the 95%-prediction band is 8.09990% for 6th February 1990, whilst the yield on that day was 8.14%. Only if 99%-prediction bands are used, would the yield of 6th February 1990 be consistent with the previous trend. However, even with this very high standard, 7th February 1990 and all subsequent days deviate from the previous trend. It is evident that 6th February 1990 is not a continuation of a previous trend but a structural change.

Thus, the event-study has shown that 6th February 1990 constitutes an event. However, this does not necessarily mean that the government's conflict with the Bundesbank was the driving force behind the dramatically rising yields. It may also be that economic agents considered Kohl's proposition of German Monetary Union an important step towards reunification. This could have led to expectations about increased demand for capital, which caused yields to rise sharply.
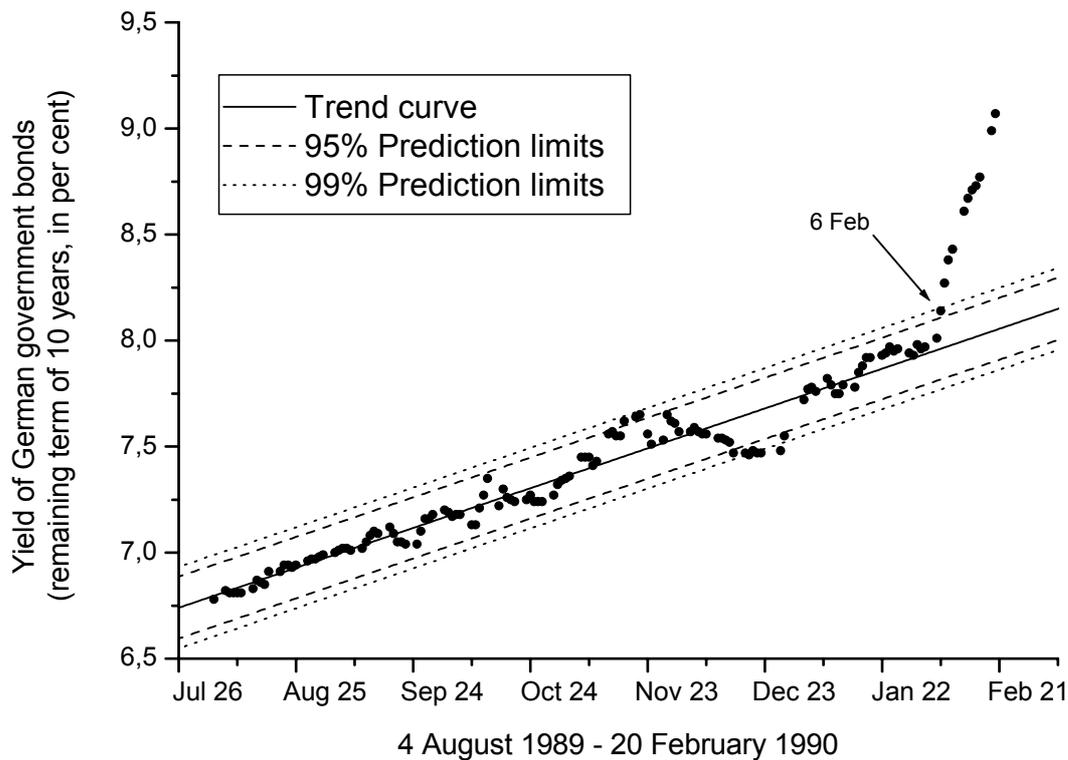
Figure 5: **Event study concerning 6 February 1990. Yields of German government bonds (remaining term of 10 years), 4 August 1989 – 20 February 1990.**

Thus, it is necessary to differentiate between rising yields due to increased demand for capital and due to inflationary expectations. As outlined under 3.2, this requires further analysis. A comparison with foreign government bonds can be helpful.
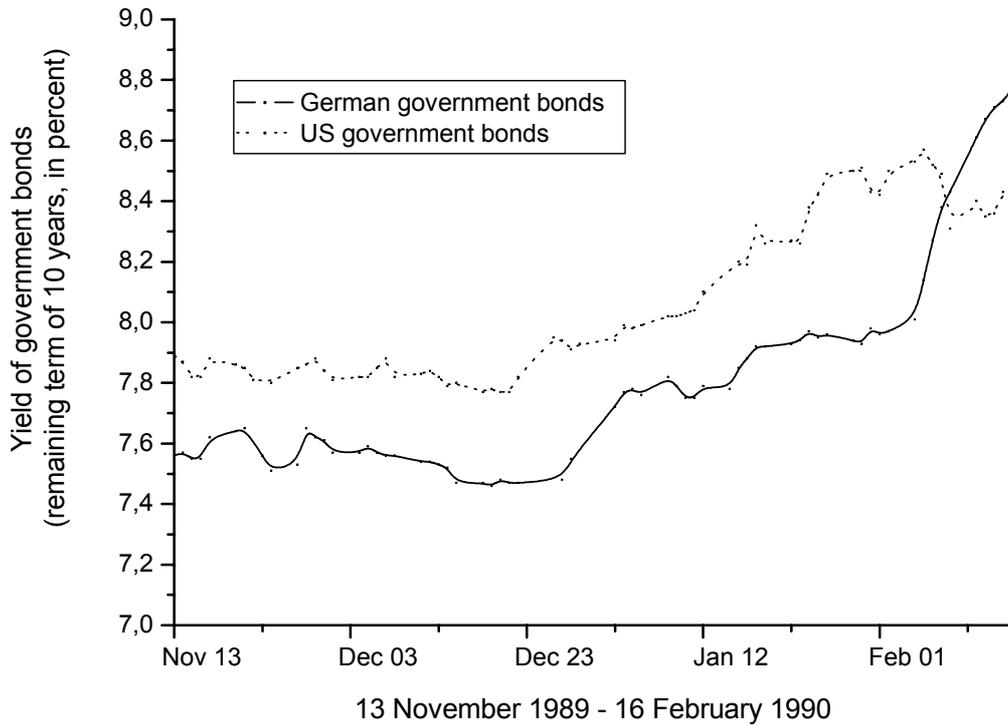
Figure 6: **Yields of German government bonds in comparison to US government bonds (remaining term of 10 years), 13 November 1989 – 16 February 1990.**

Source: Time series of the Federal Reserve Bank and the Bundesbank (unpublished; internal classifications: tcm10y and WT3055)

Rising inflationary expectations are specific to one country – in our case West Germany. By contrast, given liberalised capital markets, rising capital demand affects capital markets across the globe. Rising capital demand should therefore increase yields to approximately the same extent in different (national) capital markets. This parallel movement of yields across countries is well illustrated by figure 6 for the three months preceding 6th February 1990.

This pattern of parallel development ends abruptly on 6th February 1990. Yields are the same in both countries for the first time in 13 years[89], and German yields surpass US yields thereafter. This could lead to the conclusion that rising inflationary expectations rather than rising capital demand was the driving force behind the yield pattern of the German bond market following 6th February 1990.

However, the concept of a similar development of yields in different countries is only correct *cum grano salis*. Despite capital market liberalisations, investors still have a preference for the home market. This is partly due to higher information costs in foreign bond markets; in addition to that, there exist legal requirements that force some groups of investors to buy national rather than foreign government bonds. Therefore, rising capital demand is *de facto* primarily directed against the home market.

There are more arguments to back up the hypothesis that rising inflationary expectations rather than rising capital demand were the driving force behind dramatically rising yields in February 1990. The dramatically rising capital demand was not foreseeable in February 1990. After all, Kohl proclaimed that German Monetary Union would cost nothing. Indeed, the first public sector borrowing related to reunification was announced only in May 1990. Nevertheless, it might be natural to assume that market participants anticipated rising capital demand when Kohl proposed monetary union with a run-down communist economy. It is worth comparing 6th February 1990 with 9th November 1989 and 28th November 1989, the dates at which the Wall fell and Kohl proposed his "programme of 10 points", respectively. These two events could also have led to expectations of rising capital demand. However, increases in yields were somewhat moderate on these two days, accompanied by no significant increases during the following days (see figure 4).

Therefore, we conclude as follows. The conflict between government and Bundesbank made the German bond market extremely nervous. Yields rose sharply, more than one percentage point in less than two weeks. In particular

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[89] Deutsche Bundesbank, *Monthly Report*, June 1990, p. 15.

foreign investors lost confidence in future monetary policy, as they continued to sell German bonds during February and March to the value of 12 billion Deutschmarks.[90] As this rise affected bonds of all remaining terms, it can be interpreted that economic agents believed that inflation would increase by more than one per cent in the short, medium and long-term. The credibility of the Bundesbank and German monetary policy as a whole had suffered severely from the conflict.

Robustness checks

We have established so far that 6th February 1990 does constitute an event. This finding, however, is based on the assumption that we can reasonably approximate the yield curve in the estimation window as a linear regression of the form $Y_t = \alpha + \beta\, t + u_t$, where the disturbance term u_t follows the assumptions of the classical regression model (in particular the assumptions of non-correlation of the disturbances ($Cov(u_i, u_j)=0$ for $i=1,..., n$; $j=1,..., n$; $i \neq j$) and of homoscedasticity ($Var(u_i)=\sigma^2$ for $i=1,..., n$).

The extremely low Durbin-Watson value of 0.2672 suggests, however, the presence of (positive) autocorrelation in the disturbances. This result is reinforced by the extremely high nR^2-value of the Breusch-Godfrey Serial Correlation LM test (95.2374), which allows us to reject the null-hypothesis of non-correlation in the disturbances (even at significance levels well below 1%).

Having detected autocorrelation as a potential problem, we need to ask what this implies for what we are ultimately interested in, i.e. the estimation of prediction bands. The OLS formulae for estimating the variances of the estimators (s_F^2 in the terminology of appendix 1) become biased in this case, thus invalidating the usual OLS inferential procedures. More precisely, the bias normally leads to an underestimation of the variances of the estimators. This implies that prediction bands become narrower than they should be (cf. formula (A6) in appendix 1). Overly narrow prediction bands, however, is exactly what

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[90] Deutsche Bundesbank, *Monthly Report*, June 1990, pp. 16-17; ibid., September 1990, p. 19.

we need to be afraid of most. They could lead us to interpret the actual value of a yield (e.g. 8.14% for 6th February 1990) as evidence of an event simply because prediction bands are narrower then they should be. To make a long story short: autocorrelation poses a severe problem in our case and might even reverse our finding that 6th February 1990 constitutes an event.

The most obvious solution to our problem is to model our time series as an autoregressive process. Thus, the initial equation $Y_t = \alpha + \beta\, t + u_t$ is replaced by

$$Y_t = \alpha + \beta\, t + \varepsilon_t \tag{1}$$

with $\varepsilon_t = \varphi\, \varepsilon_{t-1} + u_t$, where u_t is IID$(0,\sigma^2)$ (2)

Equations 1 and 2 describe what is known as an AR(1) process, the order 1 relating to the fact that each disturbance is influenced (at least directly) only by the previous disturbance.

Estimation of our time series yields the results presented in table 3. Figure 7 showing actual and fitted values demonstrates that an AR(1) process represents a better approximation than the regression line in figure (4). Values on the horizontal axis represent trading days, starting as of January 1989; ##149 and 275 represent 4th August 1989 and 5th February 1990, respectively. The better closeness of fit is reflected by the improved R^2, which has risen from 0.9533 to 0.9883. The coefficients on α, β, and φ appear to be statistically significant.
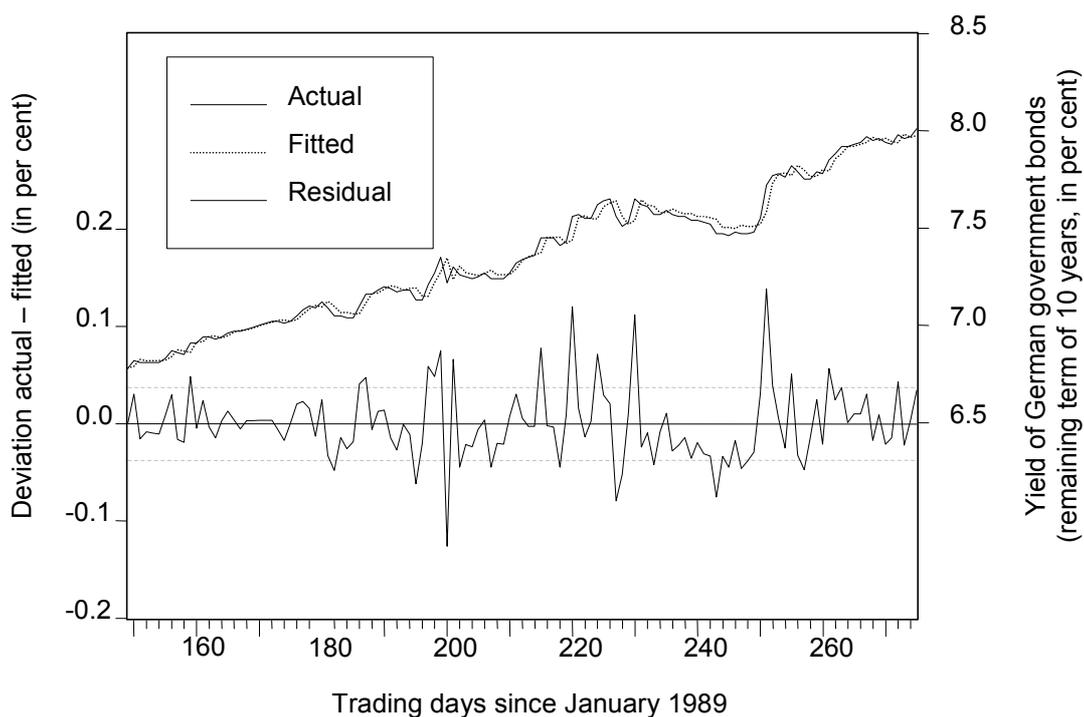
Figure 7: **Modelling the yield curve as AR(1) process subject to a time trend. 4 August 1989 – 5 February 1990 (= trading days 149-275).**

Source: Time series of the Bundesbank (unpublished; internal classification: WT3055)

Before embarking on the prediction, the question remains whether we should model our time series as a higher order AR-process. The Breusch-Godfrey Serial Correlation LM test yields an nR^2-value of 2.1152. This value is slightly below the critical value of 2.71 (10% significance level), so that we fail to reject the null-hypothesis of non-correlation. This, in turn, suggests that there is no need to opt for a higher order autoregressive process. Studying the correlogram of the yield curve points to the same result. Also, the correlogram suggests that modelling our time series as a moving average process does not make sense.

Table 3

Regression results: German government bond yields,

4 August 1989 to 5 February 1990,

assuming an AR(1) process subject to a time trend (see figure 7)

Parameter	Coefficient	Standard error	t-value
α	6.783201	0.054626	124.1764
β	0.009276	0.000696	13.33351
φ	0.869188	0.045064	19.28772
R^2	Durbin-Watson-value	BG-LM-test nR^2	F-value
0.988329	1.769947	2.115227	5250.422

Least squares estimation of equation (1): $Y_t = \alpha + \beta\, t + \varepsilon_t$, where t represents trading days and Y_t the yield on day t (t=149 corresponds to 4 August 1989 and t=275 corresponds to 5 February 1990); $\varepsilon_t = \varphi\, \varepsilon_{t-1} + u_t$, where u_t is assumed IID$(0,\sigma^2)$.

Having established an AR(1) process as a good approximation of our time series, we can now predict the hypothetical development of the yield curve on 6th February 1990 and the following days (figure 8). As in figure 5, the graph shows the actual values, the predicted values and the 95% prediction bands. Although the prediction band has a slightly different shape, the key result of our previous analysis still holds: all the actual values following 6th February 1990 fall – with a considerable margin – outside the prediction bands (6th February 1990: 8,14% as opposed to 8,08660%), thus confirming that 6th February 1990 does constitute an event.

Figure 8: Prediction based on modelling the yield curve as AR(1) process subject to a time trend. 23 January 1990 – 6 March 1990 (= trading days 266-296).

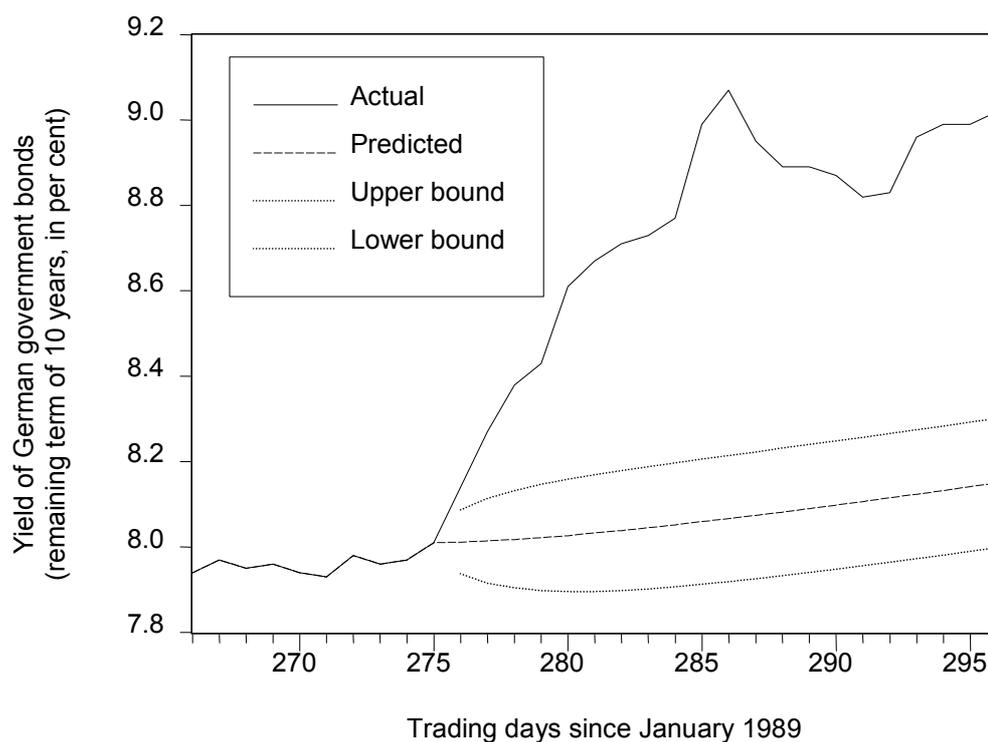Source: Time series of the Bundesbank (unpublished; internal classification: WT3055)

We have estimated our time series so far according to equations (1) and (2). As explained more in detail in appendix 2, this equation can be rewritten as:

$$Y_t = \gamma + \delta\, t + \varphi\, Y_{t-1} + u_t \text{, where } u_t \text{ is IID}(0,\sigma^2) \qquad (3)$$

Estimation of our time series yields the results presented in table 4. The coefficient on φ is identical in tables 3 and 4, whereas the coefficients on γ and δ

can be transformed into the coefficients on α and β according to the algorithm presented in appendix 2.

Table 4

Regression results: German government bonds yields,

4 August 1989 to 5 February 1990,

assuming an AR(1) process subject to a time trend

(see figure 7)

Parameter	Coefficient	Standard error	t-value
γ	0.895388	0.305659	2.929372
δ	0.001213	0.000420	2.888489
φ	0.869188	0.045064	19.28772
R^2	Durbin-Watson-value	BG-LM-test nR^2	F-value
0.988329	1.769947	2.115227	5250.422

Least squares estimation of equation (3): $Y_t = \gamma + \delta\, t + \varphi\, Y_{t-1} + u_t$, where t represents trading days and Y_t the yield on day t (t=149 corresponds to 4 August 1989 and t=275 corresponds to 5 February 1990); u_t is assumed IID($0,\sigma^2$).

The reformulated version (3) is the key to the second interpretation of our time series. In equation (3), $\delta\, t$ represents a deterministic trend and $\varphi\, Y_{t-1}$ a stochastic trend. The problem of many time series in econometric applications is, however, that it is often difficult to distinguish between time series subject to both a deterministic and a stochastic trend – as suggested in equation (3) – and time series subject to a stochastic trend only (which would imply $\delta = 0$). The distinction between the competing interpretations, however, is vital, as it has a profound impact on the prediction bands that we want to establish.

Subtracting Y_{t-1} from both sides of equation (3) leads to

$$Y_t - Y_{t-1} = \gamma + \delta\, t + \varphi\, Y_{t-1} - Y_{t-1} + u_t \qquad\qquad (4)$$

which can be reformulated as

$$\Delta Y_t = \gamma + \delta\, t + \varphi^*\, Y_{t-1} + u_t \text{ , where } \varphi^* = \varphi - 1. \qquad\qquad (5)$$

Equation (5) without the term $\delta\, t$ is the basis for the Dickey-Fuller-test for a unit root ($\varphi=1$) which allows us to distinguish between stationary and non-stationary processes. Including the term $\delta\, t$ allows us additionally to ascertain whether a time series is subject to both a deterministic and a stochastic trend or, alternatively, is subject to a stochastic trend only.[91] If a time series is estimated according to equation (5), the F-test allows to test the joint hypothesis $\delta = \varphi^* = 0$. If the critical F-value is not reached, the hypothesis cannot be rejected. This, in turn, suggests that the time series under consideration is subject to stochastic non-stationarity ($\varphi^* = 0$ implies $\varphi = 1$) without any deterministic trend ($\delta = 0$). Estimation of our time series according to equation (5) yields an F-value of 4.2445. This value, however, is below the critical F-value of 5.47 (n=100; significance level of 10%). It is worth remembering that this critical F-value – like the t-ratio referred to in the next paragraph – is not taken from ordinary F-tables, but from tables specifically designed by Dickey and Fuller for estimations according to equation (5).[92] Thus we are unable to reject the null hypothesis (even at a significance level of 10%), leaving little space for a deterministic trend.

Having shaken our belief in a deterministic trend, we now turn to the t-ratio with respect to the φ^*-coefficient (-2.9028). This t-ratio, more widely known as the augmented Dickey-Fuller test statistic (including intercept and trend in our case, cf. equation (5)), is not negative enough to reject the null hypothesis of non-

[91] R.L. Thomas, *Modern Econometrics* (London: 1996), p. 411.
[92] D.A. Dickey and W.A. Fuller, "The likelihood ratio statistics for autoregressive time series with a unit root", in: *Econometrica* 49 (1981), p. 1063.

stationarity even at the significance level of 10%, the critical value being –
3,1474.[93] This suggests that our time series is more likely to be interpreted
correctly as a unit root process.

We should now draw the conclusions from this finding and re-estimate our
time series. The two most obvious choices are equations (6) and (7):

$$Y_t = \gamma + \varphi\, Y_{t-1} + u_t \text{ , where } u_t \text{ is IID}(0,\sigma^2) \tag{6}$$

$$Y_t = \varphi\, Y_{t-1} + u_t \text{ , where } u_t \text{ is IID}(0,\sigma^2) \tag{7}$$

Estimation according to equation (6) does not yield a satisfactory result:
The coefficient on γ is statistically not significant, as the extremely low t-ratio
(0.5030; probability value of 0.6158) indicates. By contrast, estimation according
to equation (7) is more promising: Table 5 summarizes the results and figure 9
presents actual and fitted values in the estimation window.

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[93] W.A. Fuller, *Introduction to Statistical Time Series* (New York: 1976), p. 373.

Table 5

Regression results: German government bond yields,

4 August 1989 to 5 February 1990

assuming a stochastic trend (see figure 9)

Parameter	Coefficient	Standard error	t-value
φ	1.001317	0.000463	2161.983
R^2	Durbin-Watson-value	BG-LM-test nR^2	
0.987519	1.886228	0.379051	

Least squares estimation of equation (7): $Y_t = \varphi\, Y_{t-1} + u_t$, where t represents trading days and Y_t the yield on day t (t=149 corresponds to 4 August 1989 and t=275 corresponds to 5 February 1990); u_t is assumed $IID(0,\sigma^2)$.
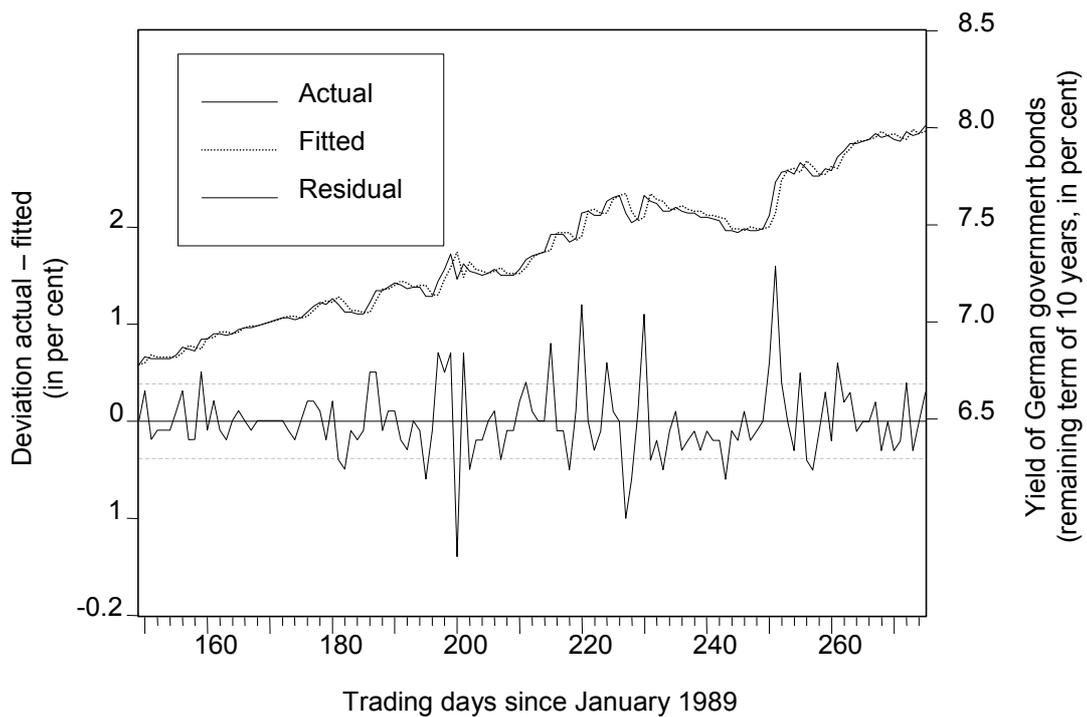
Figure 9: **Modelling the yield curve as subject to a stochastic trend. 4 August 1989 – 5 February 1990 (= trading days 149-275).**
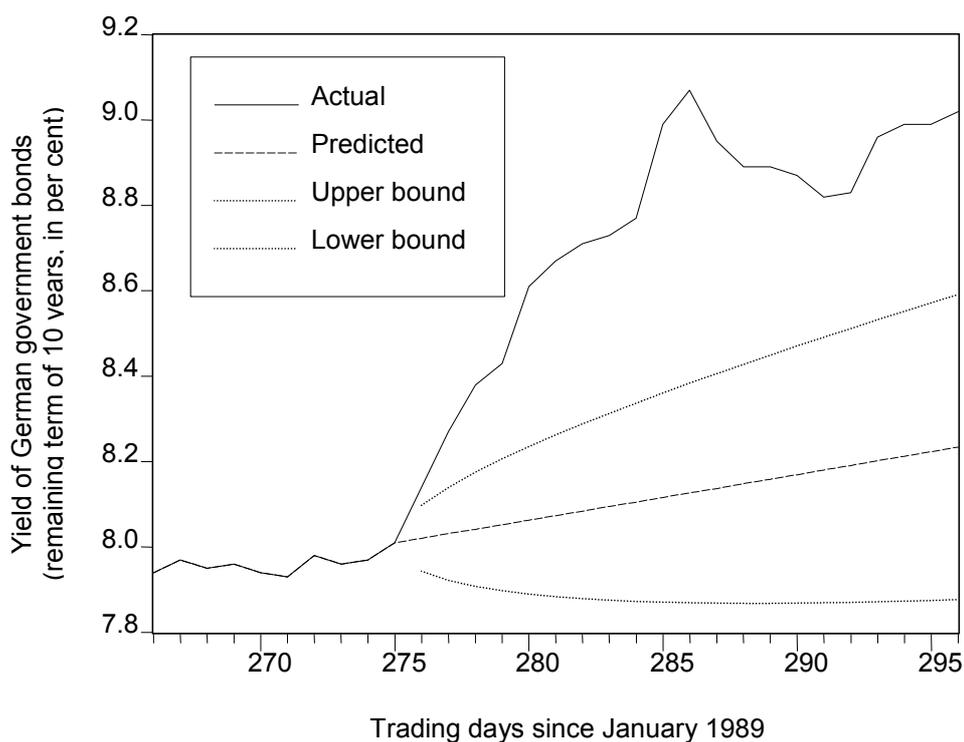
Source: Time series of the Bundesbank (unpublished; internal classification: WT3055)

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The coefficient on φ is remarkably close to 1, suggesting that our time series should be interpreted as a random walk. Figure 10 represents prediction of hypothetical yields on 6th February 1990 and the following days based on this interpretation. All actual values fall outside the estimated prediction bands.

Figure 10 differs from figure 8 in that the prediction bands become wider during the course of time. This is not surprising by any means; it merely reflects the fact that we interpret our time series subject to a non-stationary stochastic process only. Both graphs, however, coincide in that all actual values fall outside the estimated prediction bands. Therefore, we can leave the issue of the most appropriate interpretation of our time series unresolved. 6th February 1990 constitutes an event, regardless of how we interpret our time series exactly.

Therefore, we conclude as follows. We have tried out different interpretations of our time series. The most convincing ones were the AR(1)-process including a time trend and the unit root process. Both models approximate the development of the yield curve in the estimation window much better than our initial single regression model. They do, however, coincide with our initial finding in the crucial aspect: the yields of 6th February 1990 and the following days cannot be interpreted as a continuation of previous developments in the estimation window. They can only be explained by what happened on 6th February 1990 itself. Thus, regardless of how we interpret our series exactly, 6th February constitutes an event.

Last but not least, as the different interpretations do not make a difference, we will conduct the following event studies with the first procedure, i.e. determination of prediction intervals within the framework of the linear single regression.

Figure 10: Prediction based on modelling the yield curve as random walk. 23 January 1990 – 6 March 1990 (= trading days 266-296).

Source: Time series of the Bundesbank (unpublished; internal classification: WT3055)

3.3.3 Subsequent events

Notwithstanding that the dramatic rise in yields following 6th February 1990 is the most pronounced event, the development of yields is very instructive (figure 11). A technical adjustment takes place after 20th February 1990. The ensuing process of falling yields is interrupted on 1st March 1990 and reversed for some time. Afterwards, yields fall until 2nd April 1990. Then, yields rise until 2nd May 1990, only to decrease again afterwards. The month of May is characterised by ups and downs. Yields start to fall significantly in mid-June, reaching levels that had been reached since February. It is only in early August

when yields start to rise again due to the Iraqi invasion of Kuwait (2nd August 1990).
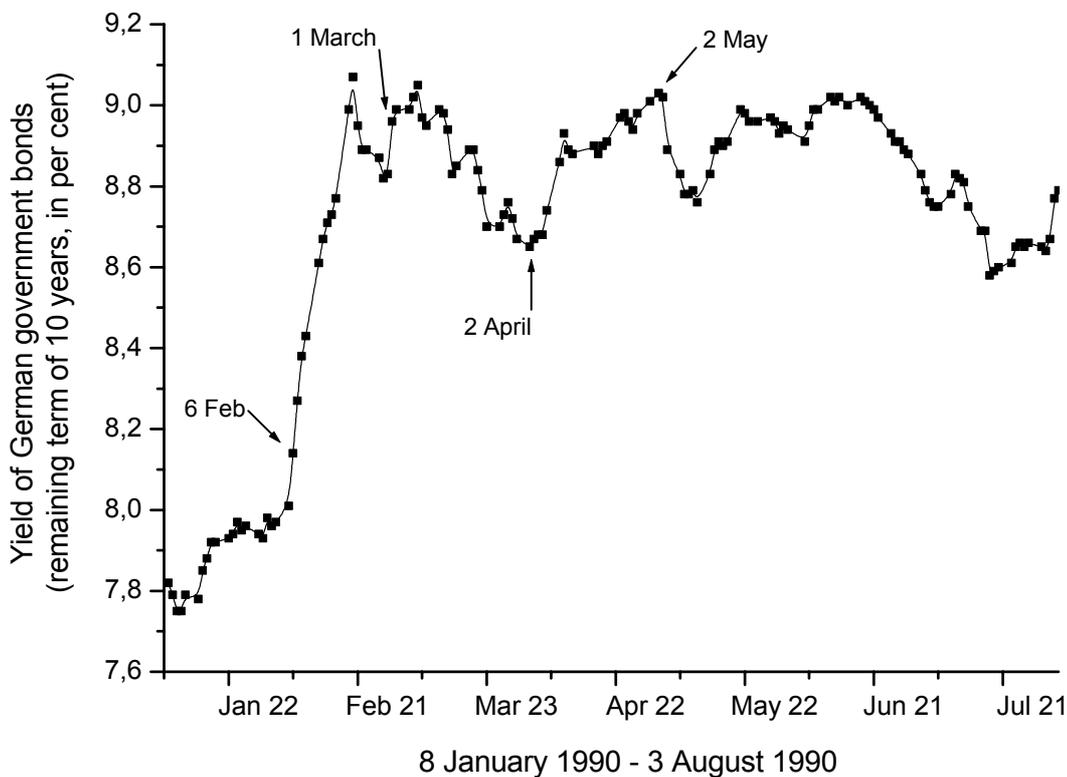
Figure 11: **Yields of German government bonds (remaining term of 10 years), 8 January 1990 – 3 August 1990.**

All of these dates are well known from the qualitative analysis and have been summarised in table 1. Let us begin with 1st March 1990. Tensions between government and Bundesbank gave rise to rumours on that day that Pöhl would step down. The bond market reacted nervously and yields rose sharply, both on 1st March 1990 and the following days.

An event study can also be conducted for 1st March 1990, the single problem being the limited number of observations in the estimation window. Due to the breakdown of the previous trend on 6th February 1990, the estimation window only contains the values after the first technical adjustment beginning 20th February 1990. From a statistical point of view, however, it is possible to estimate a previous trend and to show that 1st March 1990 deviates from this trend. As figure 12 shows, the putative intentions of Pöhl to step down can be interpreted as an event on its own.

The phase of rising yields from 2nd April 1990 to 2nd May 1990 coincides with the negotiations of the West and the East German governments on the conversion rate. The conversion rate proposal of the Bundesbank, which had leaked to the press Saturday 31st March 1990, and that of the West German government were too different and overshadowed the negotiations. Rising yields during the negotiation period reflect irritation on behalf of economic agents.

Yields fall following the announcement of the conversion rate on 2nd May 1990. This cannot necessarily be interpreted as sign of relief; the decrease is still within the margin of a typical financial market reaction once legal certainty has been achieved.

It is noticeable that the "good-weather-communiqué" of 31st May 1990 did not lead to falling yields. Credibility cannot be re-established by decision; it can only be regained gradually.The continuous decrease of yields beginning in mid-June is instructive. This might have to do with the fact that tensions calmed down. In addition to this, the introduction of the Deutschmark in East Germany on 1st July 1990 worked very well from an organisational point of view. Moreover, inflation forecasts published in early July 1990 did not suggest an immediate upsurge of the inflation rate.[94]

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[94] Deutsche Bundesbank, *Monthly Report*, September 1990, p. 90.
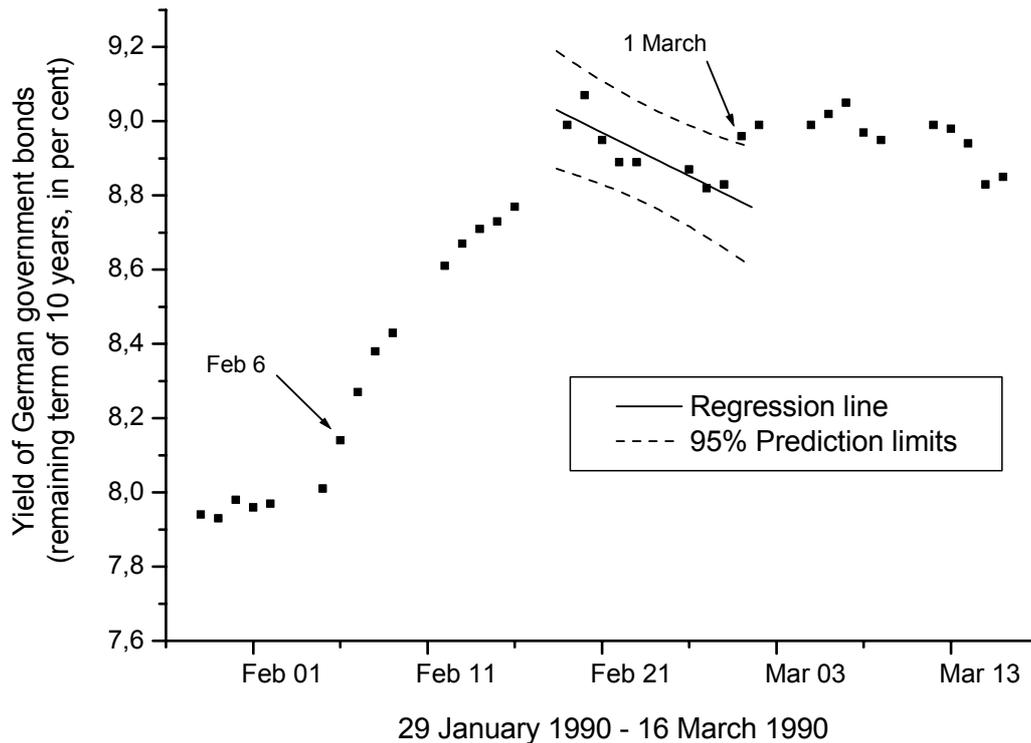
Figure 12: **Event study concerning 1 March 1990. Yields of German government bonds (remaining term of 10 years), 29 January 1990 – 16 March 1990.**

We conclude that the quantitative analysis has supported the qualitative analysis. Each of the major events of conflict between government and Bundesbank led to rising inflationary expectations on behalf of economic agents and, in turn, had repercussions in the bond market. 6th February 1990 saw the most notable event, with an increase of more than one per cent in bond yields. This should not be surprising, as it was the first conflict that caused yields to rise, so that further increases of that size were less likely.

4. The costs of lost credibility

Chapters 2 and 3 have shown that the conflict between government and Bundesbank caused German monetary policy to lose a degree of credibility. This raises the question as to whether the costs of lost credibility can somehow be estimated to show how costly such a conflict between government and central bank can be.

Such estimation requires a comparison of the actual development with the hypothetical situation in the absence of conflict. Therefore, such estimation poses problems inherent to counterfactual speculation.[95] Although these problems will always stand in the way of a precise comparison, it has often proved possible in the field of economic history to ascertain at least upper and lower bounds of costs.[96]

An estimate of the lower bound of the costs incurred by the conflict will be attempted. The starting point for this is the following: the quantitative analysis has shown that the yields of government bonds shot up 6th February 1990 – the first day of the conflict – and deviated from the previous trend. Rising yields of circulating government bonds also led to rising interest rates for government bonds issued at that time. The amount of the increase was approximately the same.[97] With the need to reschedule its debt at the time of the conflict with the Bundesbank, the government was forced to issue bonds with higher interest rates, and was required to service the interest payments for the remaining term of the bonds issued in 1990.

These costs, due to the interest rate differential in 1990, can be estimated with some reliability. However, an important assumption must be made: the hypothetical inflation rate must equal the actual rate after 1990. It is indisputable that the government needed to pay higher nominal interest rates. Does this

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[95] McClelland, *Causal Explanation and Model Building in History, Economics and the New Economic History*, pp. 146-68.

[96] R.W. Fogel, "Notes on the Social Savings Controversy", in: *Journal of Economic History* 39 (1979), pp. 1-54.

[97] Deutsche Bundesbank, *Capital Market Statistics*, February to June 1990.

necessarily translate into a higher payment of real interest rates? This would be case if the actual inflation rate after 1990 was no higher than the hypothetical inflation rate in the absence of conflict between government and Bundesbank. Therefore, the question is whether the conflict led to a higher inflation rate in the subsequent years.

The inflation rate in the early 1990s was, indeed, higher than before. Although this may be said to be due to the reunification - in particular to the large fiscal transfers to East Germany -, the slightly higher inflation rate does not seem to be the consequence of German Monetary Union as such.[98] Rather, the Bundesbank endeavoured to counteract potential inflationary risks of German currency union by its interest rate policy. Thus, the required assumption of an equal actual and hypothetical inflation pattern seems to be justifiable.

Before making the calculations it is valuable to note some costs, which are not included in our concept of a lower bound. As the foreign newspaper articles have demonstrated, there were concerns abroad about what occurred in Germany. Therefore, it is natural to assume that more capital for reconstruction would have flowed to East Germany in the absence of conflict. It is even harder to pin down potential political costs. However, it is worth mentioning that the origin of de facto collapse of the European Monetary System in 1992 and 1993 has often been located in German Monetary Union and its inflationary potential, which forced the Bundesbank to raise interest rates to levels that were not bearable for other countries.[99]

For the estimation of the lower bound of the costs, the following three variables must be multiplied: (1) the volume of issue of government bonds, (2) the average term of the issued bonds, and (3) the interest rate differential between the actual and the hypothetical interest rate development. The variables cover the

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[98] H.J. Thieme, "Währungsunion in Deutschland: Konsequenzen für die Geldpolitik", in: *Ökonomische Erfolge und Mißerfolge der deutschen Vereinigung*, ed. G. Gutmann and U. Wagner (Stuttgart, Jena: 1994), pp. 131-58.

[99] D. Cobham, "German Currency Union and the Crises in the European Monetary System", in: *The German Currency Union of 1990: A Critical Assessment*, ed. S.F. Frowen and J. Hölscher (New York: 1997), pp. 36-58. DeGrauwe, *Economics of Monetary Union*, p. 116.

period of time in which the actual interest rate was higher than the hypothetical interest rate.

The calculation of the interest rate differential is likely to be the most difficult point. The starting point of the event-study of chapter 3 was the deviation of the yield curve from the previous trend on 6th February 1990. Subsequently, trend and yield curves deviate until 29th June 1990 (Friday). It is only on 2nd July 1990 (Monday) that the trend again catches up with the actual development. Therefore, for the time in between, the interest rate differential can be estimated as the difference between the yield curve and the trend curve (figure 13).

It might be argued in opposition to this that the hypothetical yield curve would differ from the trend curve. However, given that yields had been rising for a long period before 5th February 1990 (figure 13), and that yields had reached an extremely high level by that day (8.01%), it is likely that the yield curve would have declined rather than the opposite. This would only have increased the interest rate differential, thereby enlarging the estimated costs. The assumed hypothetical yield development is therefore in accordance with the concept of a *lower* bound. The same holds for the fact that we stop the calculations on 29th June 1990. It is appropriate to assume that interest rates were still slightly higher after that date due to the credibility loss. Not taking the resulting costs in account – which would be hard to quantify – is no contradiction of the concept of a lower bound.
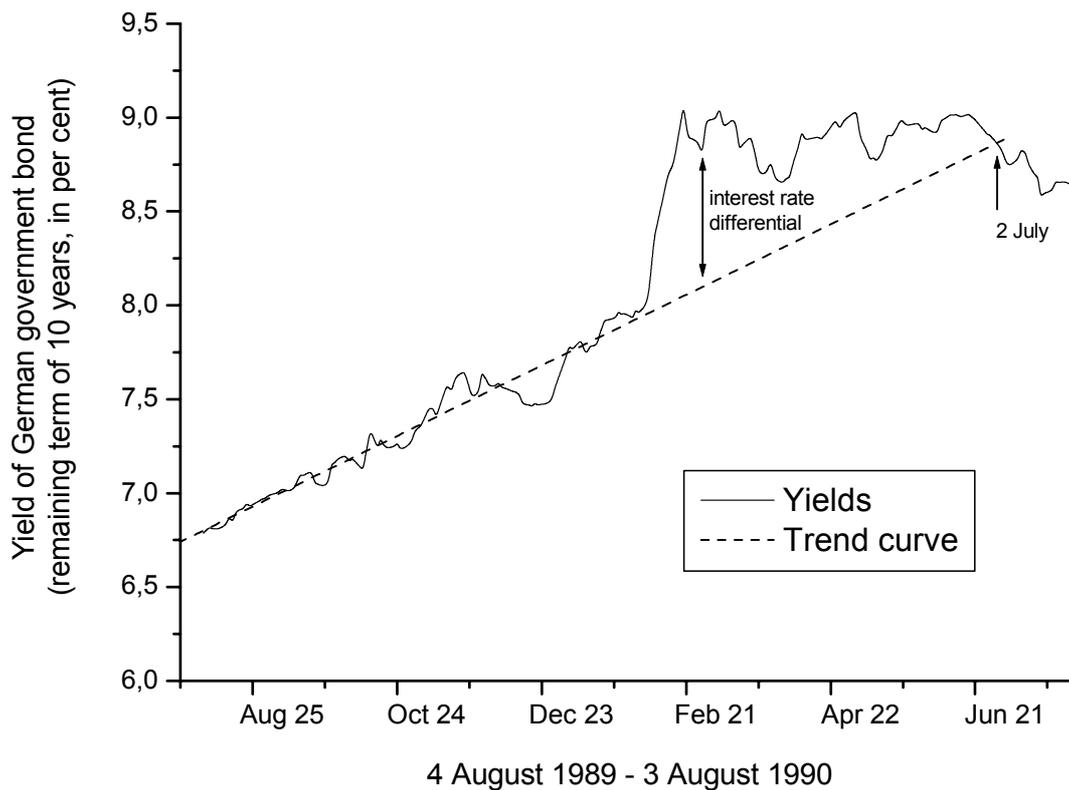
Figure 13: Interest rate differential between actual and hypothetical development, 6 February 1990 – 2 July 1990. Yields of German government bonds (remaining term of 10 years), 4 August 1989 – 3 August 1990.

Source: Time series of the Bundesbank (unpublished; internal classification: WT3055)

Data concerning the volume of issue of government bonds are only available on a monthly basis. Therefore, an average interest rate differential has been estimated for the months of February to June. The average remaining term can be calculated as a weighted average of the bonds issued from February to June 1990 on the basis of the capital market statistics published by the Bundes-

bank.[100] It is necessary to differentiate between government bonds ("Anleihen der öffentlichen Hand") and municipal bonds ("Kommunalobligationen"). Both are public sector debt from an economic point of view[101]; the statistics, however, distinguish between the two for legal reasons. It can be said *cum grano salis* that government bonds consist principally of debts at the federal level (approximately 80%), whilst communal bonds represent debts below the federal level.

The results (table 6) show that the cost of the conflict to the German taxpayer was at least 2 billion Deutschmarks. It is difficult to derive any conclusions from the lower limit we have calculated, the problem being to find any figure for comparison. It appears that calculations of the costs incurred by lost central bank credibility have not yet been attempted. Therefore, it is not possible to compare the conflict under consideration with other conflicts between a central bank and a national government and to determine whether the 1990 conflict was extremely costly or not.

This leaves only the possibility of comparing the results with other kinds of governmental expenditures. Costs of German reunification have surpassed by far what politicians initially thought they would be; yearly fiscal transfers to East Germany are estimated to be about 150 billion Deutschmarks.[102] In comparison with this figure, the estimated lower level appears rather moderate.

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[100] Deutsche Bundesbank, *Capital Market Statistics*, February to June 1990, p. 13.

[101] A.B.J. Siebers and M.M. Weigert, eds., *Börsenlexikon* (Munich, Vienna: 1995), pp. 231, 66-67. Deutsche Bundesbank, *Capital Market Statistics*, February to June 1990, p. 57; ibid., August 2001, pp. 63-64.

[102] Giersch and Sinn, "Zusammenwachsen heißt zusammen wachsen".

Table 6

Lower bound of costs (in million Deutschmarks)

incurred by the credibility loss of the Bundesbank

(6 February 1990 – 29 June 1990)

	February[4]	March	April	May	June	Total
Government bonds						
Volume of issue[1]	6104	7911	9436	15105	6246	44802
Average term[2]	6.92	6.74	8.01	7.42	5.87	
Interest rate differential[3]	0.6769	0.6771	0.4705	0.3213	0.1962	
Costs	285.772	360.996	355.467	360.248	71.876	1434.360
Municipal bonds						
Volume of issue	4809	5964	4285	4263	2946	22267
Average term	6.26	5.31	5.28	5.16	4.79	
Interest rate differential	0.6769	0.6771	0.4705	0.3213	0.1962	
Costs	203.731	214.607	106.389	70.628	27.694	623.049
Total						
Volume of issue	10913	13875	13721	19368	9192	67069
Average term	6.63	6.13	7.15	6.92	5.52	
Interest rate differential	0.6769	0.6771	0.4705	0.3213	0.1962	
Costs	489.503	575.603	461.857	430.876	99.570	2057.409

[1] In million Deutschmarks.
[2] In years.
[3] In per cent.
[4] Calculations for February take into account that only 17 out of 20 trading days were affected by the divergence from the previous trend.
Source: Calculated from Deutsche Bundesbank, *Capital Market Statistics*, February to June 1990, 13.

Nonetheless, it is worth comparing our results with what politicians initially thought German reunification would cost. The first public borrowing was announced in May 1990 and entailed the issue of government bonds for the value of 95 billion Deutschmarks over the course of four years.[103] This was then believed to cover all costs related to German reunification. From this perspective, the costs incurred by lost credibility amount to more than two per cent of total costs related to German reunification, thus forming a substantial part of the expenditures on German reunification.

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[103] Grosser, *Das Wagnis der Währungs-, Wirtschafts- und Sozialunion*, p. 201.

5. Conclusion

This paper has shown that Bundesbank and German monetary policy had a major credibility problem in 1990. The origin was the conflict over German Monetary Union and the need for an appropriate conversion rate. Whilst the West German government was in favour of a conversion rate based on social and political considerations, the Bundesbank drew attention to the potential for inflationary consequences of such a solution and advocated a conversion rate based on economic criteria. Beside this difference of opinion, there were two – albeit subsidiary – centres of conflict. First, the Bundesbank expressed concerns over the long-term economic consequences of German reunification and blamed the government for downplaying potential problems. In particular, the Bundesbank was afraid that expansive fiscal policy due to reconstruction in East Germany could undermine the pursuit of strict monetary policy. Second, the Bundesbank believed that the behaviour of the West German government could act as a negative signal for a future European Central Bank. As negotiations on European Monetary Union were soon to begin, the Bundesbank raised the issue of whether the German government would still advocate an independent European Central Bank after what had occurred with the national central bank.

The causes of conflict were two different concepts of what a central bank is supposed to do. The government did not violate the Bundesbank's independence as granted in the Law on the Bundesbank. This was its only concern. By contrast, the Bundesbank had a much wider concept of its own task. It cared about long-term price stability and reliability of German monetary policy. In this regard, it expressed concerns over potential threats to price stability arising from the three conflicts shown above.

The quantitative analysis has supported the findings of the qualitative account. The central concept was to measure inflationary expectations of economic agents and to use these expectations as a proxy for central bank credibility. The inquiry into German government bond yields has demonstrated

that all major events during the conflict caused yields to rise sharply. This holds in particular for the first clash on 6th February 1990, which led to an increase in yields of more than one per cent. The estimation of a lower limit of costs incurred by lost credibility has delivered the impressive figure of more than 2 billion Deutschmarks.

As measuring central bank credibility requires further improvement, it is important to point out to potentials and pitfalls of the method applied in the quantitative part of this paper. The core concept, to measure inflationary expectations, is a good starting point, since the economic rationale behind central bank independence is precisely to reduce inflation. Thus, a major credibility problem can be inferred from dramatically rising inflationary expectations and can be detected with the help of an event study.

The pitfall of this concept is that it does not allow an inquiry into long-term credibility of a central bank. There is no fully convincing procedure to measure inflationary expectations of economic agents over a long period of time.[104] In this case, it is hardly possible to differentiate between the four factors, which make up the yield, i.e. real interest rate, inflationary expectations, expectations about the exchange rate development, and default risk.

This methodological problem is evident when we try to ascertain whether the Bundesbank's credibility was undermined in the long-run by the 1990 conflict. Qualitative argument is all that is possible. There are several arguments against a permanent credibility problem for the Bundesbank. First, the Bundesbank stuck to its concept of money supply targeting. The Bundesbank continued to publish a money supply target based on the estimations of the additional production potential in the year to come. At the end of each year, the Bundesbank verified whether the money supply target had been reached or not.[105] Given the fact that most money supply targets were fulfilled, investigations have

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[104] Cf. footnote 79.
[105] E.g., Bundesbank, *Monthly Report*, July 1991, pp. 14-17.

come to the conclusion that the monetary policy of the Bundesbank did not change after 1990.[106]

It is even more important in our context to emphasise that the Bundesbank's monetary policy not only remained the same, also it was not impeded by the national government after the events of 1990. German Monetary Union, massive fiscal transfers to East Germany and dramatically rising public debt entailed potential for inflation. This led the Bundesbank to raise interest rates to extremely high levels in the aftermath of German reunification. As this level of interest rates was unsustainable for several major European countries, it made the exchange rate mechanism of the EMS collapse de facto in 1992 and 1993. This setback for European integration efforts was embarrassing for the German government, as the European Monetary Union process was launched at the same time. Nevertheless, the German government did not ask the Bundesbank to reduce interest rates. Quite the reverse: when several European countries wanted Germany to reduce interest rates in early September 1992, immediately before the September crisis, the German government made clear that it could not act, as interest rates were set by the Bundesbank.[107] As the example of 1992 shows, the 1990 conflict did not cause the Bundesbank to lose credibility in the long run. It appears that economic agents were deeply worried about the Bundesbank's credibility in 1990, but changed their opinion afterwards, presumably considering the specific circumstances related to the formation of German Monetary Union a one-off event without any predictive power for future relations between Bundesbank and national government.

One question remains: what could have been done in 1990 to avoid the conflict between government and Bundesbank? As political reunification was imminent, German Monetary Union was unavoidable, notwithstanding that gradual economic convergence may have been better from an economic point of view. Thus, a conversion rate had to be found.

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[106] Thieme, "Währungsunion in Deutschland: Konsequenzen für die Geldpolitik".
[107] Cf. Gros and Thygesen, *European Monetary Integration*, pp. 95-96.

The government's aim was to improve social conditions in East Germany with the help of a favourable conversion rate. This was a good solution from a politician's point of view. Any kind of fiscal policy would have made clear to the West German public that reunification was not for free. An alternative to what happened in 1990 might have been the following. The governments of the two Germanys agree upon a conversion rate determined by economic criteria. This would have avoided potential for inflation and would have led to greater competitiveness of East German companies. At the same time, the taxpayer could have subsidised East German wages to improve social conditions. In reality, however, the German government stuck to its position that tax increases were not necessary. It is not unfair to assume that this was partly due to federal parliamentary elections in December 1990.

The answer to the counterfactual question of how the 1990 conflict could have been avoided leads us back to the economic rationale behind central bank independence. The government ought not to have the opportunity to avoid unpopular fiscal measures and to finance expenditure by printing money. With reference to German Monetary Union, this implies that only economic criteria should have guided the search for an appropriate conversion rate. At the same time, the government should have faced the costs of German reunification early on and, in turn, should have solved them by appropriate means, i.e. fiscal policy.

Appendix 1: Determination of prediction intervals within the framework of the linear single regression

It is not possible to say that the hypothetical value for 6th February must be on the regression line itself. This would deny the fact that not only the trend, but also a certain variation around the trend determines the yield. However, it is possible to use the estimated trend and the estimated variation from the estimation window to ascertain a prediction interval, in which the hypothetical values of the event will be with a probability $1 - \delta$. If the real values of the event window are found to be outside the predicted bands, it can be said *e contrario* that the surprise event has had a significant impact on the yields with a probability of $1 - \delta$.

The pairs of value from 4th August 1989 to 5th February 1990 with their corresponding yields are interpreted as a sample from a higher population. This population also encompasses 6th February 1990. Under certain assumptions – in particular the assumptions of homoscedasticity (Var(U$_i$)=σ_u^2 for i=1,..., n) and the non-correlation of the disturbance variables (Cov(U$_i$,U$_j$)=0 for i=1,..., n; j=1,..., n; i≠j) –, it is possible to infer from the sample prediction intervals for the population, including 6th February 1990 and the subsequent days.

The central principle of the sample model of the linear single regression is that the values of the dependent variable y$_i$ – the yield in our context – can be understood as the sum of a systematic component linear in x$_i$ – the time in our context – and a disturbance term u$_i$:

$$y_i = \alpha + \beta x_i + u_i \tag{A1}$$

where α and β denote the regression coefficients of the linear regression function of the (hypothetical) population. The disturbance term u$_i$ represents the deviation of the value y$_i$ at x$_i$ from the value of the regression function of the population at x$_i$. The totality of u$_i$ describes the variation of the yield development around the trend as characterised by the regression line of the population. It possibly also

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describes the impact of all other variables which have an impact on the yield but have not been explicitly incorporated into the set of explanatory variables. Within the framework of the sample model, the disturbance variable u_i at x_i is interpreted as a random realisation of the random variable U_i which is characterised by a normal distribution. Therefore, the y_i also must be interpreted as random realisations of a normal-distributed random variable Y_i:

$$Y_i \ = \ \alpha + \beta x_i + U_i \tag{A2}$$

It is not, as a consequence, possible to predict the value y_i of the variable Y_i for 6th February 1990. On the basis of the model, it is only possible to say with which probability $W = 1-\delta$ the value y_i will be found within certain prediction limits.

However, it is essential therefore that the standard deviation s_F for the variable Y_i can be determined. As can be shown, a relationship between the (for the moment unknown) standard deviation s_F of the individual prediction value y_i and the standard deviation of the residuals s_E of the sample can be established under certain assumptions:

$$s_F{}^2 \ = \ s_E{}^2 \left\{ \ 1 + \frac{1}{n} + \frac{(x_0 - \bar{x})^2}{\sum\limits_{i=1}^{n} (x_i - \bar{x})^2} \ \right\} \tag{A3}$$

where n is the number of (x_i, y_i)-pairs of the sample, $\bar{x}$ arithmetical mean of the x_i-values of the sample and x_o the value whose y-value is to be predicted.

The standard deviation of the residuals s_E is given by

$$s_E{}^2 \ = \ \frac{1}{n-2} \sum\limits_{i=1}^{n} e_i{}^2 \tag{A4}$$

The e_i –values represent the deviations of the y_i-values from the regression line of the sample:

$$y_i \ = \ a + b \, x_i + e_i \tag{A5}$$

NB: The regression coefficients a and b of the sample are not identical with the values α and β of the population from which we only have a sample which can be analysed. Therefore, the e_i do not correspond with the u_i.

Prediction limits:

Using the standard deviation s_F of the normal-distributed random variable Y_i, it is possible to determine a prediction interval for the expected individual value y_o for any significance level $W=1-\delta$:

$$\hat{y}_o - t \cdot s_F \leq y_o \leq \hat{y}_o + t \cdot s_F \tag{A6}$$

$\hat{y}_o$ denotes the y-value which corresponds to x_o on the regression line (as estimated from the sample, i.e. the estimation window). The parameter t is a specific value, which can be taken from a student's t distribution table[108] with reference to the significance level $W=1-\delta$ and the number of degrees of freedom (n-2).

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[108] W.H. Greene, *Econometric Analysis*, 4th ed. (London: 2000), p. 958.

Appendix 2: Identity of equations (1) and (3)

We have argued in the main text that equations (1) and (3) – reproduced here as equations (A7) and (A8), respectively – are merely two different representations of one and the same time series Y_t. In this section, we will show how to transform equation (A8) into equation (A7).

$$Y_t = \alpha + \beta\, t + \varepsilon_t \qquad \text{with } \varepsilon_t = \varphi'\, \varepsilon_{t-1} + u_t \tag{A7}$$

$$Y_t = \gamma + \delta\, t + \varphi\, Y_{t-1} + u_t \tag{A8}$$

Subtracting $\varphi\, Y_{t-1}$ from both sides of equation (A8) leads to

$$Y_t - \varphi\, Y_{t-1} = (1 - \varphi\, D)\, Y_t = \gamma + \delta\, t + u_t \tag{A9}$$

where D is a lag-operator, by which the time series value Y at t is transformed into the value at t-1: $D\, Y_t = Y_{t-1}$. The advantage of lag-operators in our context is that they allow algebraic transformations as if they were variables. The reader not accustomed to the use of lag-operators may obtain the same result with the help of conventional backward substitution, a procedure which is obviously more tedious.

Dividing (A9) by $(1 - \varphi\, D)$ yields

$$Y_t = \frac{1}{1 - \varphi\, D}\, \{\gamma + \delta\, t + u_t\} \tag{A10}$$

The factor $\dfrac{1}{1 - \varphi\, D}$ is now interpreted as the sum of a geometric series with the q $= \varphi\, D$. Thus, equation (A10) can be reformulated as

$$Y_t = (1 + \varphi\, D + \varphi^2\, D^2 + \varphi^3\, D^3 + ...)\, \{\gamma + \delta\, t + u_t\} \tag{A11}$$

or, alternatively, as

$$Y_t = (1 + \varphi\, D + \varphi^2\, D^2 + \varphi^3\, D^3 + ...) \{ \gamma + \delta\, t \}$$
$$+ (1 + \varphi\, D + \varphi^2\, D^2 + \varphi^3\, D^3 + ...)\, u_t \qquad (A12)$$

Multiplying out the first summand and leaving the second summand unchanged yields

$$Y_t = \qquad\qquad \gamma + \quad \delta\, t$$
$$+ \quad \varphi\, \gamma + \quad \varphi\, \delta\, (t\text{-}1)$$
$$+ \quad \varphi^2\, \gamma + \quad \varphi^2\, \delta\, (t\text{-}2)$$
$$+ \quad \varphi^3\, \gamma + \quad \varphi^3\, \delta\, (t\text{-}3)$$
$$+ ...$$
$$+ (1 + \varphi\, D + \varphi^2\, D^2 + \varphi^3\, D^3 + ...)\, u_t \qquad (A13)$$

Rearrangement leads to

$$Y_t = \gamma\, (1 + \varphi + \varphi^2 + \varphi^3 + ...)$$
$$+ \delta\, (1 + \varphi + \varphi^2 + \varphi^3 + ...)\, t$$
$$- \varphi\, \delta\, (1 + 2\varphi + 3\varphi^2 + ...)$$
$$+ (1 + \varphi\, D + \varphi^2\, D^2 + \varphi^3\, D^3 + ...)\, u_t \qquad (A14)$$

which can be transformed into

$$Y_t \quad = \gamma\, \frac{1}{1-\varphi} + \delta\, \frac{1}{1-\varphi}\, t - \delta\, \frac{\varphi}{(1-\varphi)^2}$$
$$+ (1 + \varphi\, D + \varphi^2\, D^2 + \varphi^3\, D^3 + ...)\, u_t \qquad (A15)$$

Whereas the transformation of the first two summands follows the pattern suggested above (A10&A11), the transformation of the subtrahend takes advantage of the differentiation of a geometric series:

$$\frac{d}{d\varphi}\frac{1}{1-\varphi} = \frac{d}{d\varphi}(1 + \varphi + \varphi^2 + \varphi^3 + ...) = 1 + 2\varphi + 3\varphi^2 + ... = \frac{1}{(1-\varphi)^2}$$

Rearrangement of (A15) yields a formula that, for the first time, shows clearly that (A7) and (A8) are merely two different representations of one and the same time series Y_t:

$$Y_t = \frac{1}{1-\varphi}\gamma - \frac{\varphi}{(1-\varphi)^2}\delta + \frac{1}{1-\varphi}\delta\, t$$
$$+ (1 + \varphi D + \varphi^2 D^2 + \varphi^3 D^3 + ...)\, u_t \qquad (A16)$$

It only remains to be shown that the last summand is identical to the last summand of (A7), which we remember to be

$$\varepsilon_t = \varphi'\, \varepsilon_{t-1} + u_t$$

A similar arrangement to the one made above (A9&A10) yields

$$\varepsilon_t - \varphi'\, \varepsilon_{t-1} = (1 - \varphi'\, D)\, \varepsilon_t = u_t \qquad (A17)$$

$$\varepsilon_t = \frac{1}{1-\varphi' D}\, u_t = (1 + \varphi'\, D + \varphi'^2 D^2 + \varphi'^3 D^3 + ...)\, u_t \qquad (A18)$$

Thus, the terms ε_t of (A7) and u_t of (A8) are identical. Hence, we can conclude that (A7) and (A8) are two different representations of one and the same time series Y_t. We conclude this section with the formulae obtained how to transform the coefficients γ, δ, and φ of equation (A8) into the coefficients α, β, and φ' of

equation (A7). The reader may verify the obtained formulae for the regression results presented in tables 3 and 4, respectively.

$$\alpha = \frac{\gamma}{1-\varphi} - \frac{\varphi\,\delta}{(1-\varphi)^2} \qquad\qquad\qquad (A19)$$

$$\beta = \frac{\delta}{1-\varphi} \qquad\qquad\qquad (A20)$$

$$\varphi' = \varphi \qquad\qquad\qquad (A21)$$

For the transformation of equation (A7) into equation (A8) we obtain the formulae:

$$\gamma = (1-\varphi')\,\alpha + \varphi'\,\beta \qquad\qquad\qquad (A22)$$

$$\delta = (1-\varphi')\,\beta \qquad\qquad\qquad (A23)$$

$$\varphi = \varphi' \qquad\qquad\qquad (A24)$$

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