The European Monetary Union: the effects of policy coordination

Master's thesis

Imke Dilven (s4458168)

Abstract

This thesis contributes to the extensive line of research about the role of coordination in the European Monetary Union. In a one-country model, Alesina and Tabellini (1987) look at the role of coordination between the fiscal and monetary authority. Beetsma and Bovenberg (1998) look at the coordination between fiscal authorities in the setting of a monetary union. They find that a setting with more fiscal authorities which are not coordinated is beneficial. By analysing these two theoretical models, this thesis tries to expand this model to other settings and includes different assumption. This is done by expanding the paper by Alesina and Tabellini (1987) to a two-country model and to change the rules of the game in the model by Beetsma and Bovenberg (1998). This thesis finds that fiscal leadership strengthens the position of the fiscal authority and leads to outcomes closer to the preferences of this authority. The beneficial results by Beetsma and Bovenberg (1998) in a setting with uncoordinated fiscal authorities is not supported by this thesis.

Key words: European Monetary Union, monetary policy, fiscal policy, game theory

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Radboud University

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1. Introduction

Even in the early developments of the European Monetary Union, the different governments involved were not always likeminded (Bean, 1992). The loss of sovereignty when imposing fiscal rules was a big obstacle and not all countries experience the same benefits and losses when introducing a monetary union or when imposing fiscal policy mechanisms. However, after the recent financial crisis, the discussion about fiscal policy became stronger (Schaechter, Kinda, Budina, & Weber, 2012). Countries disagreed, amongst other things, on the timing of fiscal measures when recovering from a financial crisis and the balance between rigidity and flexibility (Barrios, Langedijk, & Pench, 2010). Some even argued that the big differences between regulatory systems within the European Monetary Union are at the heart of the financial crisis within the Eurozone (Moloney, 2010). However, even after the financial crisis there was strong disagreement on how this had to be solved. Overall, there was a common agreement that the financial system should become more stable and centralized on some parts. However, how this had to be done is a remaining question since all reforms will have benefits as well as possible problems.

Besides the political attention and disagreement about fiscal rules and fiscal coordination, there is also still disagreement in the theory. The existing literature disagrees on the role and the effect of fiscal coordination within monetary unions (Dixit & Lambertini, 2003). While some authors claim that fiscal coordination is needed to prevent fiscal authorities from generating too much debt, others claim that fiscal rules are preventing governments from bouncing back from financial crises. Also, some argue that without fiscal coordination, fiscal policymakers will be disciplined by having only one monetary authority. It remains up for debate what kind of policy would be optimal in a monetary union to promote growth while also leaving enough room to recover after asymmetric shocks. Therefore, this thesis tries to answer the following research question: 'Is the economy of the European Union better off in a scenario with coordination amongst member states?'.

This is done by an analysis of two important articles in the literature about monetary and fiscal policy. First of all, Alesina and Tabellini (1987) discuss coordination between the fiscal and the monetary authority is in a one-country model. In their paper, they show that moving from discretionary policymaking towards a situation in which the monetary authority can make a binding commitment will not always be welfare improving, and in some cases even decrease welfare, for one or more of the players in the game. Beetsma and Bovenberg (1998), in their article, discuss that the lack of coordination amongst fiscal authorities in a monetary

union will keep these separate fiscal authorities in check. The lack of fiscal coordination will make the fiscal authorities aware that they have little influence on the inflation rate and will, therefore, prevent them from increasing tax rates, which, they argue, would prompt the monetary union to increase inflation. This thesis analyses the mechanisms behind these papers and tries to bring these theories and models together to shed more light on the different aspects of fiscal coordination. This is done through theoretical and analytical reasoning.

The model by Beetsma and Bovenberg (1998) is moved to a situation with simultaneous decision making of the fiscal and monetary authority. This leads to a decrease in power of the fiscal authority, moving to an outcome that is less beneficial for the fiscal authority. The model by Alesina and Tabellini (1998) is expanded to a two-country model with the help of the model by Beetsma and Bovenberg (1998). However, the beneficial effects of uncoordinated fiscal policymakers on the inflation rate that is found by Beetsma and Bovenberg (1998) does not become visible in the new model.

This thesis starts off with a literature review of fiscal and monetary policymaking and the interaction between these two. Furthermore, the European Monetary Union and the current literature on fiscal coordination and fiscal rules are discussed. Thereafter, two main articles in this field, one by Alesina and Tabellini (1987) and one by Beetsma and Bovenberg (1998), are discussed and commented upon. Subsequently, these papers are compared, and elements of these papers are transferred to expand the models. Lastly, this thesis comes to a conclusion about these results and possible limitations of the models are discussed. Also, this thesis gives some suggestion for further research on this topic.

2. Literature review

2.1 Fiscal policy

As indicated earlier, the fiscal systems are not the same in all European Countries and sometimes have different guidelines or mechanisms. Research often claims that the main goal of fiscal policy is the provision of public goods. However, some argue that fiscal policy also fosters an important countercyclical role to stabilize the economy (Dixit & Lambertini, 2003). Wyplosz (2002) even claims that this would be one of the most important challenges for fiscal policy. As a result, countercyclical adjustments are also the main reason fiscal policy would deviate from the initial path. For the European Monetary Union this poses an important challenge. Fiscal policy in Europe is determined by separate countries, but there are some rules that these countries have to apply to (Schaechter et al., 2012). However, it becomes difficult

when not all countries agree on when it is permissible to deviate from the set of rules and guidelines.

Fiscal policy can be described as expansionary, in the case that taxes are decreased, or government spending is increased, or contractionary when these forces work in the opposite direction. However, the ultimate results from these two policy options are debatable (Andrés & Doménech, 2006). The effects of fiscal expansions are generally positive for output levels because of the decrease in production costs. This decrease comes from lower tax rates or the subsidies for companies that could boost production and make it less costly. Nonetheless, this does not undoubtedly imply that a fiscal constraint hinders output and could not lead to positive outcomes (Baldacci, Cangiano, Mahfouz, & Schimmelpfennig, 2001). Fiscal contractions are often accompanied by an improvement in the terms of trade which might decrease the cost of imported resources or lead to increased profit from exported products. Furthermore, some empirical evidence suggests that in advanced economies a contractionary policy even comes with expenditure increases but recessions with expansionary fiscal policies are accompanied by higher growth levels.

But what makes a fiscal policy successful? The results of fiscal policy are mainly visible in the short run (Zagler & Dürnecker, 2003). Because of that, it would be reasonable to measure its' performance based on how well they are able to decrease fluctuations in output and unemployment levels. However, the pronounced influence on short run equilibria does not mean that the policies do not have a lasting effect (Zagler & Dürnecker, 2003). A straightforward example would be investments in education. Even if these investments are short term, they could promote the skills of students and turn into a benefit for society when they join, he workforce. Thus, this fiscal policy measure could have a long-term positive effect on human capital. Until this point, the fiscal policy is mainly discussed from an economic point of view. However, conducting fiscal policies has an important political side (Wyplosz, 2002). Compared to monetary policy, it is not that easy to adjust policies because the fiscal authority does not act independently. Important and structural changes will be discussed in the parliament and have to be approved. This results, in some cases, in an adjusting process that takes too much time. The reaction to a shock can, therefore, come too late. Furthermore, an important part of fiscal policy is the reallocation of income which asks for a democratic base. The election of fiscal authorities is also closely linked to the willingness of fiscal authorities to stay with their commitment (Wyplosz, 2002). When the public finds it important to follow that the fiscal authorities stick to their promises, they are more likely to do so to improve their chances to be re-elected.

2.2 Monetary policy

Because of the democratic base, fiscal policy has another background than monetary policy since this is in general more independent. Monetary policy also has other objectives and many would consider the primary goal to manage price stability (Berger, De Haan, & Eijffinger, 2001). This role, which can be executed by different institutions, is primarily reserved for a central bank. The central bank, which is in many cases independent, has, in general, a strong mandate to ensure the stability of prices. The independence of the central bank is seen as important because of the inflationary bias the government faces (Fischer, 1995). This bias would result in a very high inflation rate in the absence of a central bank that operates independently. This comes, in many cases, with a policy that has one main objective, namely the inflation rate target. In the case for the EMU, there is one central bank that decides on the monetary policy for the entire monetary union.

An independent central bank is not the same as a conservative central bank (Berger et al., 2001). Where independent central banks are not influenced by politics and are operating on their own, the degree of conservativeness demonstrates how strong the inflation objective of the central bank is. Thus, a conservative central bank does not necessarily have to be independent. Moreover, a central bank that is independent on paper, does not automatically imply that they are really independent and that they are not influenced in any way (Beetsma and Bovenberg, 1998). A central bank that is legally independent might still be influenced because of incomplete laws (Cukierman, 1994). This problem is, in general, more pronounced in less developed countries where the legal system is less powerful. In the case of the European Monetary Union, the central bankers of the European Central Bank come from different countries. Even though the idea was that the views of the governors of the central bank would converge and EU socialization would take place, this is not always the case. Van Esch and De Jong (2019) found that, except for the president of the central bank, the governors of the central bank are still not completely socialized towards the EU and influences from their home country are still visible.

However, even if a big part of the literature agrees on the importance of the inflation target, this does not mean that it is commonly agreed that this is the sole objective of the central bank. Rogoff (1985) investigates that although it is beneficial for the central bank to put more weight on inflation than society does, an infinite weight will make the economy vulnerable for shocks. Cukierman (1994) indicates that after price stability, the second objective of the central bank should be the stability of the financial system. Furthermore, the central bank in the EMU

also looks at the output levels and the interest rate levels (Surico, 2007). In general terms, the central bank should support the economies of the member states with high employment levels and sustainable long-term growth. This makes it relevant how these objectives coincide with the fiscal policies within the EMU.

2.3 Discretionary policymaking or commitments

Given the fiscal and monetary policy objectives, the question comes to mind how these policies should be formed. The way policy, both fiscal as well as monetary, is conducted is generally divided into discretionary and non-discretionary policy. Within discretionary policymaking, the policymaker decides what is best given current circumstances as well as the expectations about the future (Kydland & Prescott, 1977). Naturally, there are several ways how these expectations can be formed. Moreover, the economic system is very dynamic and also dependent on expectations. If a monetary regime is discretionary, for example, the monetary authority would have the possibility to move to a higher level of inflation without the public expecting these inflation rates because the monetary authority is able to deviate (Barro & Gordon, 1983).

The discretionary regime does not automatically result in the outcomes that is best in the social objective function. Since the policies are constantly optimized considering the current events, these policies can lead to instability and the planning of policy might be suboptimal (Kydland & Prescott, 1977). However, the discretionary regime could also be complemented with reputational benefits and costs (Barro & Gordon, 1983). The idea of losing credibility could be a driver, for example for the central bank, to commit to a goal in the long term without expropriating the benefits of short-term higher inflation. A commitment regime, in contrast to a discretionary regime, is based on targets where authorities can commit themselves to in a credible manner. The differences between these two types of policymaking come with variations in outcomes, which will also become clear from the analysis of the article by Alesina and Tabellini (1987).

2.4 Developments in the European Monetary Union

In order to fully understand the aspects of the discussion about the coordination of fiscal policy in the European Monetary Union, it is helpful to look back at the developments of the union itself and the regulations associated with this monetary union. The European Monetary Union (EMU) is not the only monetary union in the world, but it is one of the most well-known

ones and most often discussed in the literature. On 1 January 1993, the European community was set to become a single integrated market (Bean, 1992). The national barriers had been abolished to get to a situation of free movements of goods and labour and the Delors Commission received the task to assess whether a monetary union would be beneficial. At that time, the European Exchange Rate Mechanism held the exchange rate close together and this rate could only fluctuate within a certain band.

The advice of the Delors Commission was that a single market needs a single currency to fully reap the benefits the single market can bring. Within the Maastricht Treaty, signed in 1992, the convergence criteria for the EMU were described (R. M. W. J. Beetsma & Bovenberg, 1999). Examples of these criteria are a maximum level of public debt and fiscal deficit. The role of these restricting features of the Maastricht Treaty was to trim down the excessive debts when countries were on their way to become a monetary and economic union (Von Hagen & Eichengreen, 1996). However, some countries had to work hard to be able to comply with the Maastricht criteria. This led to fiscal policy that became less counter-cyclical than it was before the convergence criteria were installed (Wyplosz, 2002). In some cases, fiscal policy even has become pro-cyclical. Once a country is in the monetary union, they also have a maximum on the fiscal deficit which is imposed by this Maastricht Treaty (Von Hagen & Eichengreen, 1996). Important to note is that these rules still had room for larger deficits in economic difficult times. However, not everyone agrees with the fit of the rules made on the fiscal policy objectives (Buiter, Corsetti, Roubini, Repullo, & Frankel, 1993). Some argue that the fiscal restrictions are too tight and inflexible to changes. The rules are, according to some, failing to correct for, for example, business cycles or real growth.

Because of the rules imposed at the beginning of the formation of the EMU, the differences between inflation rates within the prospective Euro area decreased significantly (Lane, 2006). At the time the situation was evaluated, and the monetary union was initiated, not all countries did strictly comply with the criteria and Greece could only join later on in the process. The European Member States agreed that there was a need for more coordination of the national fiscal and economic policies. In 1998 the Stability and Growth Pact (SGP) was introduced to place limits on budget deficits and accumulated debt (Lane, 2006). When all countries share one currency, excess debt might lead to a recession in the whole European Union, even in the countries with lower debt levels. The goal of the Stability and Growth Pact was to keep a close eye on the debt situation of all member state and punish those with debt levels that seemed too high (R. Beetsma & Uhlig, 1999).

In the investigation of the Delors Commission, one of the important outcomes had already been the need for binding fiscal rules amongst member states (Bean, 1992). But on the other hand, the independent fiscal policy has been important in the process because this would give the individual countries room to react to possible shocks (Lane, 2006). The original Stability and Growth Pact came to an end in November 2003 because of disagreement on the surveillance of the rules. The revisited Stability and Growth Pact was established in 2005. Not surprisingly, this version had more flexibility on the rules and at which times these rules should come into play. The fact that the fiscal policy is tied to democratic decision making and also includes income distribution, has made decisions about a fiscal framework within the European Union increasingly difficult (Wyplosz, 2002).

Once the EMU was created, this did not mean that the inflation rate differentials completely came to an end (Lane, 2006). The prices between countries still varied and, in the beginning, they even varied more than they did before the Euro was introduced. This means that you can pay with a Euro everywhere, but from country to country the number of products that you can buy for this Euro will vary a lot. The countries within the EMU vary, amongst other things, in their structure and output levels (Lane, 2006). Because of these differences, growth rates are also not equal across the Euro-area which gives rooms for asymmetric shocks. The effects of creating a monetary union are not equal for all countries. They are also no longer able to strategically influence exchange rates.

There are two important losses associated with the movements towards a monetary union (Bean, 1992). First of all, there was a big loss of seigniorage income in countries which had experienced very high inflation rates before. Because of this lower inflation rate standard, countries needed to trim down their deficits and debt levels because the costs of these debt levels were no longer decreased by inflation rates. Secondly, there was no longer room for decreasing or increasing exchange rates for macroeconomic purposes. Countries that are more open to international trade outside the European Union will be more affected by policy decisions and changes in the exchange rate of the Euro (Lane, 2006). Furthermore, peripheral countries were more influenced by this steep decline in interest rates. Fast increased lending and house market booms asked for higher inflation which was, after the EMU was created, no longer possible.

One of the most important benefits of the EMU, on the other hand, is the decreased exchange rate volatility and exchange rate risk (Bean, 1992). This is especially important for companies that often trade across borders of the EMU and thus have to move their goods from country to country. Moreover, the monetary unification boosts the credibility of the European

Union (Bean, 1992). When there is one unifying currency, it becomes harder to leave the union compared to the situation before the EMU was initiated. Therefore, the European Union would reap benefits from their increased credibility in the long run since the political power of the union will increase.

An important turning point for the EMU and the Euro was the financial crisis. Although the monetary policy was working well and the economy was growing at a fast pace, there were already some warning signs (Dabrowski, 2019). The member states did not always comply with the fiscal rules that were set by the central bank. However, the rules and regulations that were set by the SGP were not checked often enough. Also, it was easier to drift away from the rules after the relaxation of the SGP in 2005. After the financial crisis, Europe has revisited its fiscal rules and policies (Schaechter et al., 2012). The financial crisis has let to countries drifting away from the limits that were initially imposed. These new rules, issued after the crisis, are aimed to make a better balance between sustainability and flexibility in policies. Furthermore, the aim of these rules is to create a better mechanism to react to shocks. During the financial crisis, countries which have imposed rules to prevent large fiscal deficits will in general benefit from those rules since they enable countries to react quicker to deficit shocks (Poterba, 1993). After the financial crisis, the debate on the future of the EMU became stronger (Dabrowski, 2019). There is a lot of disagreement what this future should look like and one of the important reforms, the banking union, is stuck because of the disagreement about the design of the union. The differences between countries on how handle the financial crisis can partly be traced back to cultural differences (Bohn & de Jong, 2011). Thus, the debate on the optimal setting in the EMU and the appropriate rules for individual countries is still relevant.

2.5 Fiscal coordination

The sections above described a variety of trade-offs in developing monetary and fiscal policy both in the EMU as well as in general. Some claim that if there is an inflationary incentive in discretionary policymaking, a monetary unification would increase the debt levels. The reason for this is that the fiscal authority will, with a larger monetary union, feel a decrease in the perceived benefit of cutting their debt level (Beetsma and Bovenberg, 1998). The commitment towards inflation by the central bank will not become a credible solution to inflation rates (Hall & Franzese, 1998). When wage bargaining is not centralized, the lower inflation rates will only come at the costs of high unemployment levels. A line of research argues that if a country would be able to influence the world prices and the real interest rate, it is desirable that countries cooperate on fiscal policy (Chari & Kehoe, 2007). Furthermore, some

argue that there could be a free-riding problem within a monetary union. Because of this free riding, there are higher levels of inflation which makes debt cheaper, leading to excessive debt levels. This would call for strict rules regarding debt constraints.

When all countries decide upon their fiscal policies separately, the cumulative responses might be suboptimal (Lane, 2006). And even if all countries are deciding on these fiscal policies separately for their own country, this does not mean that the fiscal policy will be isolated. Fiscal policy can spillover to neighbors in a variety of ways, both positive as well as negative (Dixit & Lambertini, 2003). For example, an expansionary fiscal policy which increases demand for goods could spill over to neighboring countries by the increased demand for import products or the lower prices for the export products. An example of a negative externality would be an increased interest rate which hurts spending behavior. For positive externalities, this results in too many restrictions in the noncooperative equilibrium. For negative externalities, on the other hand, this will lead to equilibria with more deficits and increased spending. On the other hand, Buiter et al. (1993) found that there are no empirical arguments that these externalities are leading to a bias towards higher deficits. According to the authors, empirics cannot explain why the European Union should take see the externalities as a big concern.

However, fiscal coordination, fiscal centralization or more fiscal rules do not only have positive outcomes. When fiscal policy would really become more centralized, individual countries will also start demanding more services from the European Union (Von Hagen & Eichengreen, 1996). This, in turn, would likely hurt the financial position of this union. In times of trouble, this will increase the pressure posed in terms of bailouts in Brussel. Thus, centralized fiscal policy might turn the European Monetary Union into a sinking ship. Furthermore, as noted earlier, the separate fiscal policy mechanisms can also be used as a stabilizer (Andrés & Doménech, 2006). When ruling this possibility out from a country perspective, this might hurt the economy. Even though the fiscal rules that are already imposed are doing well, they are also criticized for limiting stabilization processes too much (Andrés & Doménech, 2006).

In terms of economic growth, the fiscal rules could be harmful and could also prevent economies from climbing out of a crisis (Wyplosz, 2002). For example, when enforcing a strict debt to GDP ratio, this could lead to problems in times of financial crises since the policy could become pro-cyclical (Schaechter et al., 2012). In times of crisis, governments might want to stimulate the economy with investments while these rules would be pushing their decisions to cut down their budgets. This, in turn, could make the financial crisis worse because disposable income could go down or costs of production could go up. Furthermore, economic instability might make it increasingly difficult to come up with the correct fiscal target when introducing

a rule (Kumar et al., 2009). The targets are mostly general, and this could lead to incentivizing the government to reduce expenses which are easiest to cut to compile with the rules instead of moving to the optimal policy. Or, in more extreme cases, the rules might result in creative accountancy practice which hurts overall transparency and trust. Also, some argue that these rules will not be necessary when the central bank could commit to its goals (Chari & Kehoe, 2007). They argue that when commitment by the monetary authority is possible, the fiscal authorities are not incentivized to higher debt levels since they know that they will not get an advantage out of levels of inflation.

There has been some previous research to models that look at the interaction between monetary and fiscal policy and a monetary union with separate fiscal policies. For example, Dixit and Lambertini (2003) model the mechanisms of fiscal and monetary policy within the European Union. However, their model is created under the assumption that the fiscal and monetary authority agree on the optimal output and inflation levels. They claim that this assumption is defendable because of the expected integration within the monetary union, which might be hard to defend.

3. Fiscal and monetary coordination by Alesina and Tabellini (1987)

3.1 Background and goal of the model

This section will go into debt about the paper written by Alesina and Tabellini (1987), called the 'Rules and Discretion with Noncoordinated Monetary and Fiscal Policies'. This paper looks at coordination, but not in their case between the fiscal and monetary authority. This model is a three-player game and in this game, they focus on taxes. This paper looks in the differences between a situation in which fiscal and monetary policy are not coordinated and in the situation in which these two authorities are coordinated. Coordination is here seen as the weights the fiscal and the monetary authority put on inflation targeting with respect to other objectives. Different than in the article by Beetsma and Bovenberg (1998), this article considers a one-country model. The novelty of this paper is that tax distortions are made explicit in the model which gives the authors the possibility to get to the influence distortionary taxes have on the outcome.

Alesina and Tabellini (1987) explicitly focus on the role taxes can play in the determination of inflation rates and in the interaction between the monetary and fiscal authority. The authors assume that the monetary authority would like a lower level of unemployment than the natural level of unemployment. This can be seen in a Barro Gordon model in figure 1 in the following way. The natural rate of outputs is lower than the bliss point of the central bank. This

bliss point represents the preferred output level by the central bank. The curves around the bliss point represent the preference curves for the central bank and the curves that lay closer to the bliss points yield a higher utility level. Thus, the central bank would want to move output up to get closer to their bliss point which creates an inflationary bias. But, if there is another way for the central bank to get to this bliss point, the central bank would lose its incentive to increase inflation. The authors argue that one alternative way to get to this output level is with the use of non-distortionary taxes. The money from this tax can be used to subsidize firms to boost employment. In other words, this tax could lead to the same unemployment level as imposed by the central bank through inflationary targeting. The specification of the tax to be non-distortionary is not without reason. If a tax rate were distortionary, this influences the choices made by individuals and firms. A non-distortionary tax, on the other hand, leaves the choices for investment and saving decisions the same (Kneller, Bleaney, & Gemmell, 1999). Furthermore, the growth rate is not negatively influenced which implies that there would be no indirect negative effect on unemployment levels that could offset the subsidy for firms.

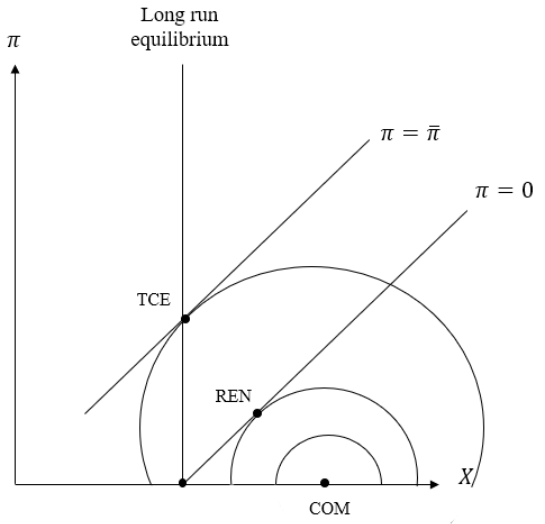

Figure 1 Barro Gordon model for output (X) and inflation π

Apart from the trade-off between output levels and inflation, the analysis of Alesina and Tabellini (1987) also pays attention to other policy outcomes. In assessing the policy outcomes, the authors also consider output, government spending and taxes to evaluate the positive or negative effects of a policy change. This emphasizes that lowering inflation is not an outcome on its own. While previous research has considered a set-up that lowers inflation as welfare improving, this paper also looks at the other sides of this story and shows that a policy regime could even worsen welfare outcomes when the rate of inflation decreases.

3.2 Game theoretic model

The paper uses a game theoretic model to explain the movements and trade-offs in the policy game. In this model, there are three players: the central bank, the fiscal authority and the wage setters. First, the role of the separate players is discussed. The wages setters operate in a wage union and will set the wage for the next period. This means that during the period, the wage that has been set cannot be changed after the inflation rate becomes known. The wages

depend on the wage target, which is equal or greater than zero, and the expected price level. The expectations made by the wage setters are rational. This leads to the wage equation below:

$$w_t = p_t^e + \upsilon_t \quad (1)$$

The nominal wage rate is taken as a log here, which means that the value captures the percentage change. This simple function shows the assumption that there is no quantity dimension in the supply for labor. When the wage target is reached, all labor that is demanded will be supplied. When the target, υ, is equal to zero the changes in the wage rate will be equal to the changes in the expected price level for the next period. This situation corresponds with a fully competitive labor market. However, when the wage target, υ, becomes positive, this will lower output level. This mechanism will be further explained later on. The goal of the wage setters is to minimize the difference between the wage target and the nominal wage for period t. The wage setters only care about wage rates, but do not care about the unemployment levels.

Alesina and Tabellini (1987) restrict their model in such a way that the only sources of revenue are non-distortionary taxes, issued by the fiscal authority, and seigniorage income which is controlled by the monetary authority. Thus, the two authorities determine together how many resources there are available for the government. By restricting the model in this way, the government cannot issue debt to pay for their expenses. Because of this, an important dimension in the intertemporal decision making by the fiscal authority is taken away. The impact of this restriction will be further elaborated on at the end of this chapter. The government budget constraint is thus only dependent on tax income, which is measured as the tax rate multiplied by the total output of all firms in the country, and seigniorage income, which is measured as the growth in money supply:

$$g_t = \tau_t + \pi_t \quad (2)$$

The fiscal authority can only influence the aggregate supply through its policy but does not have any influence on the money demand. The supply function is made up of the difference between inflation and expected inflation, the tax rate and the wage target:

$$x_t = \alpha(\pi_t - \pi_t^e - \tau_t - \upsilon) \quad (3)$$

The way the fiscal authority influences the supply function here, is through the tax rate, τ, which also appeared in the government budget constraint above. This tax rate is a tax on the total revenue of firms. Within the model, Alesina and Tabellini (1987) see fiscal policy as endogenous; it is determined within the model and influenced by the reaction functions of the other two players. Because the fiscal authority cannot influence money demand, they are not

subjected to time inconsistencies. The fiscal authority is elected and therefore has to defend their choices to the electorate. Because of this, the fiscal authority is assumed to put, relative to the monetary authority, more weight on the output objective and the public spending objective. The loss function for the fiscal authority can be described with the equation below. Note that the fiscal authority has three objectives; the height of inflation, the level of output and the deviation of government spending from its target.

$$V^{FA} = \left(\frac{1}{2}\right) \sum_{t=0}^{T} \theta^{t} [\pi_t^2 + \delta_1 x_1^2 + \delta_2 (g_t - \bar{g})^2] \quad (4)$$

The monetary authority, the third player in the game, will be independent from the government. The monetary authority is therefore not influenced by voting decisions of the public. The monetary authority completely controls the inflation rate but will also attach value to the other societal goals, namely government spending and output levels. In this model, money creation by the central bank only benefits the seigniorage income. The model has the simplifying assumption that real interest rates are not affected. The implications of this assumption will be discussed more into debt later on. The central banks' loss function is stated below and has similar components as the loss function of the fiscal authority.

$$V^{CB} = \left(\frac{1}{2}\right) \sum_{t=0}^{T} \beta^{t} [\pi_t^2 + \mu_1 x_1^2 + \mu_2 (g_t - \bar{g})^2] \quad (5)$$

The targets for inflation and for output are normalized to zero. For output, a target of zero is equal to a situation with a competitive market. For the government spending, the target should be equal to or greater than zero. When the target is greater than zero, both authorities would want to raise tax rates or inflation to finance the higher level of government spending, which also becomes clear from equation (2). Alesina and Tabellini (1987) assume that the weight that the fiscal authority attaches to inflation, relative to the other two objectives, is never higher than the relative weight the monetary authority puts on inflation. For the model to hold, the government spending objective and/or the wage objective should be bigger than zero. Under these circumstances, both authorities would want to raise inflation to get to their output target. However, they have different ideas about what the policy mix between the tax rate and inflation rate should be. All players have rational expectations and take the loss functions of the other players into account while deciding on their policy instrument. Furthermore, the players move simultaneously.

3.3 A discretionary regime

The paper by Alesina and Tabellini (1987) first uses the model in a setting with a discretionary regime. Within the discretionary regime, there are no credible commitments made by the two authorities and all players choose the action that is best considering the current circumstances and future expectations. All three players act as a Nash player here, which means that the players will take actions while considering the other players' responses. The game repeats itself a finite number of times and is static so that all players act simultaneously. In other words, none of the players know for sure what the moves of the other players are. There is only one subgame perfect equilibrium and, therefore, this equilibrium is the same as the equilibrium for one-shot games. Within the Nash Equilibrium, there are no outcomes where anyone of the players could move to, to make themselves better off when the other players stick to their decisions. However, this does not imply that the Nash Equilibrium is the social optimal outcome. Hence, with reputational mechanisms, a more beneficial equilibrium would be sustainable. Nonetheless, Alesina and Tabellini (1987) do not consider this force in their model.

As explained earlier, the wage setters are fully rational, and they are aware of the possible inflationary bias of the central bank. Since the wage setters are aware of the preferences of both authorities, they take them this into consideration in their expectation of inflation. As figure 1 above shows, they are aware that the central bank has a bliss point that is away from the long-term equilibrium rate of inflation. This results in the central bank having an incentive to renege on the zero inflation and move to the 'reneging equilibrium', notable as 'REN'. Because the wage setters are aware of this bias, the wage setters increase their wages in the bargaining process which results in an equilibrium which moves to the time consistence equilibrium, marked by TCE. Alesina and Tabellini (1987) show that the government budget constraint and the output equation, combined with the preferences of both authorities, would lead to policy outcomes for the government spending gap, output and inflation. First of all, the distance between the government spending target and actual government spending, $(g_t - \bar{g})$, is positive. In other words, government spending is lower than its target. Secondly, the output level has been normalized to zero, but the policy outcome is smaller than zero. This shows that the output levels are lower than the target. Lastly, the inflation target, which is also normalized to zero, is positive which means that the inflation level is above target. In conclusion, even though inflation is higher than its target, this does not contribute to getting the other outcomes to their target levels. In other words, the level of inflation is unnecessarily high. The absolute level of these outcomes depends on the relative weight attached towards the different objectives, output and government spending, and the difference between the objectives of both authorities.

Within the policy outcomes, both the preferences of the fiscal authority as well as the monetary authority are included. The authors assume that the monetary authority is particularly inverse to inflation. This assumption would be in agreement with general theory that the monetary authority's main aim would be, or even should be, keeping inflation low (Berger et al., 2001). In this case, the weights for the other two policy objectives, government spending (μ_2) and output (μ_1), would be lower than the weight that the fiscal authority has for these objectives. Regarding the government budget constraint, which is tied to the government spending goal, the central bank would be less willing than the fiscal authority to pay for the government spending with seigniorage income because this would result in higher inflation. The central bank would prefer here to stay close to the target of inflation, which is zero, instead of increasing government spending. However, the fiscal authority would want to get government spending closer to the target because of the political position the fiscal authority is in. Therefore, they would raise the taxes a bit to compensate for the decreasing seigniorage income. This increase in taxes, in turn, would lower output. In the case for the output objective, this would be best explained by the Barro Gordon model, shown in figure 2. When the central bank is more conservative, and thus is more focused on the low inflation rate, the preference curves surrounding the bliss point will become flatter. The figure on the right-hand side illustrates a more conservative central banker. In the scenario with a more conservative central bank, the time consistent equilibrium (TCE) goes down, which corresponds with a lower inflation rate. The authors conclude that a more conservative central bank is better, since there would be less unnecessary inflation.

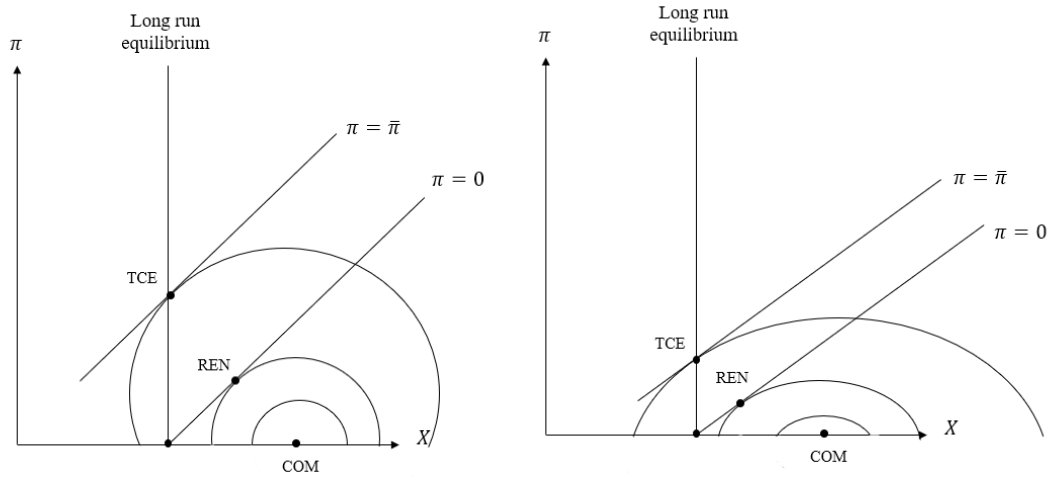

Figure 2 Barro Gordon model compared to a situation with a more conservative central bank

3.4 A binding commitment regime

In the discretionary regime, policy actions and wage setting are static games where all authorities make rational expectations about the actions of the others. However, when the central bank has a binding commitment from which they cannot deviate, the monetary authority acts in a way as a first mover. The central bank commitment is known to the other two players before they make any decision and they also believe that the central bank will stay with this commitment. This gives the central bank a role as a Stackelberg leader. The authors include this new setting in the following way. Before taking the first order condition of the fiscal and monetary authority to get to the policy outcomes, all players can already know that the monetary authority does not deviate. Therefore, before taking the first order condition, the inflation rate is equal to zero which makes it disappear out of the first order condition. After that, the authors use the first order conditions in the same way as described before. Below, the equilibrium policy outcomes of the binding commitment regime are compared to the outcomes under a discretionary regime that have been discussed earlier. Within figure 1, the binding commitment regime can be found at COM. The subscript *d* in the equations below corresponds with the discretionary regime while *c* refers to a regime under a binding commitment by the central bank. Differences between the outcomes are marked in bolt.

$$(\bar{g} - g^d) = \alpha^2\delta_1(\upsilon + \bar{g})/[\alpha^2\delta_1(1 + \mu_2) + \delta_2(\mathbf{1} + \boldsymbol{\alpha^2\mu_1})] > 0 \quad (6a)$$

$$(\bar{g} - g^c) = \alpha^2\delta_1(\upsilon + \bar{g})/[\alpha^2\delta_1(1 + \mu_2) + \delta_2] > 0 \quad (6b)$$

The equations above compare the two government spending gap outcomes. In the outcome for the commitment regime, the last term, which includes the weight the monetary regime puts on output ($\boldsymbol{\mu_1}$), of the equation has disappeared. In other words, how much the monetary authority values the output objective does not influence the size of the government

spending gap anymore. The part of the equation that is removed, $(1 + \alpha^2\mu_1)$, will always be greater than one. Thus, when this part is no longer there, the numerator of the equation becomes smaller. Henceforth, the outcome of the equation for the government spending gap in the commitment regime will be bigger than it was in the discretionary regime. Since government spending goal, $\bar{g}$, stays the stame this implies that government spending is lower in the commitment regime.

$$x^d = -(\delta_2/\alpha\delta_1)(\bar{g} - g^d) < 0 \tag{7a}$$

$$x^c = -(\delta_2/\alpha\delta_1)(\bar{g} - g^c) < 0 \tag{7b}$$

The output equation stays the same for both equilibria. However, since the component of government spending is included in the equilibrium equation, the differences in the government spending equation will carry out through the output equation. As stated earlier, $(\bar{g} - g^c)$ is bigger in the commitment regime than in the discretionary regime. In the output equation, this implies that the output level becomes more negative in the commitment regime.

The last of the three policy outcomes is the inflation rate. This is where the biggest difference in the equations arises, since the commitment made to the level of inflation by the central bank has the biggest influence here.

$$\pi^d = [(\boldsymbol{\mu_1\delta_2} + \boldsymbol{\mu_2\delta_1})/\boldsymbol{\delta_1}](\bar{g} - g^d) > 0 \tag{8a}$$

$$\pi^c = \boldsymbol{\mu_2}(\bar{g} - g^c) > 0 \tag{8b}$$

The first term of the policy outcomes has changed and will be bigger in the discretionary regime. However, in the commitment regime, the second term has become bigger through the changes in the government spending equilibrium. Comparing both changes, the changes in the first term will be stronger, leading to a lower rate of inflation in the commitment regime. This result will make clear intuitive sense, since the monetary authority in this equilibrium will commit itself to a low level of inflation.

Lastly, the changes in the tax rate that are associated with the regime change can be interesting. When looking back at the government budget constraint, $g_t = \tau_t + \pi_t$, inflation becomes lower. The level of government spending, as stated earlier, also becomes a bit lower. However, the fiscal authority has been chosen by the public. As a result, they would not settle for a very big change in government spending from its target and thus the decrease in government spending will not be fully proportional to the decrease in inflation. Hence, the tax rate under a commitment regime will become somewhat higher in the commitment regime to compensate for the lower seigniorage income.

In summary, within the binding commitments regime the inflation rate, output level and government spending become lower. On the other hand, the tax rate becomes higher. The fiscal authority raises taxes to compensate for the losses in seigniorage income. The trade-off the fiscal authority faces between public expenditure and tax expenditure becomes worse with a commitment regime. Because of the raise in taxes, output also becomes lower. The commitment regime is thus not beneficial when the welfare gains from a reduction in inflation are smaller than the losses the authority faces from the decreases in output and public spending. Thus, if the two authorities are not coordinated, or in other words, the weights for public spending and output levels are not the same for both authorities, the fiscal authority can be made worse off with a commitment regime. Even the monetary authority can be made worse off in the commitment regime if the losses due to the decrease in output levels or the increase in the government spending gap are bigger than the gains for inflation. Since the wage setters do not care about the level of unemployment but only about their wages, they would have no preferences for either of the two regimes. Hence, moving to a commitment regime can become a pareto distortion since it would be possible that no players will become better of while at least one of the players has been made worse off.

3.5 Critical reflection

As stated earlier, the model by Alesina and Tabellini (1987) assumes that the expected inflation rate only influences the wage targets and expected output. Money creation therefore only results in a seigniorage income. However, the effect that inflation has on the money demand has been ignored. This is often referred to as the Tobin-Mundell effect (Kormendi, 1985). When the public expects a high level of inflation, holding money would be less attractive since it decreases in value. Therefore, it would be more interesting to invest in capital holdings since this investment would hold its value for a longer period of time. This lowers the demand for money and thus the real interest rate. Within the government budget constraint of the model, the government budget constraint consists of the tax rate and the inflation rate. However, government debt could also be considered as a source of government income. Since issuing debt is not possible here, the government cannot choose to spend more today to pay the loan back in the next period. Therefore, the model ignores an important part of intertemporal decision making. When issuing debt is possible, the fiscal authority could further influence the inflation rate. Moreover, Chari and Kahoe (2007) argue that debt could play an important model in this argument because of the high social costs of debt. Furthermore, as reflected upon in the

literature review, debt levels are an important reason for fiscal rules. Those arguments together suggest that the analysis of Alesina and Tabellini (1987) falls short in this aspect and miss out on an important point of political discussion.

As discussed earlier, this paper does not include the possibility for the central bank to build further on its reputation. When the central bank can build a reputation over time, it will be able to gain the trust of society with choices made in earlier periods to increase their credibility (Backus & Driffill, 1985). This result in an outcome at the commitment equilibrium, without real commitment. Therefore, the central bank could still use surprise inflation when this is needed because the public expects the central bank to respond in a different way. However, after surprising the other players with inflation once, the reputation that was built is gone. If the central bank wants to use surprise inflation again, they should start building their reputation again. Since this paper includes a repeated game, the reputational mechanism is relevant. If the central bank has the opportunity to build reputation, the equilibria will not be constant over time because of the possibility to surprise the other players with inflation after the reputation of the central bank is strong. In the paper, the authors argue that the outcome of the game is the same as the one-shot game. However, this will not hold in a setting with reputational forces. For example, Tabellini (1988) looks at the reputational forces in a two-player game where the wage setters and the monetary authority are interacting over the level of the real wage. In that model, the central bank would be willing to choose a noninflationary policy even though the wage rate would be higher than optimal for the central bank. The central bank will hold this equilibrium because the outcome will be better in the long term. However, in the last period the central bank will always inflate because there is no use in a reputation for the future. Thus, when Alesina and Tabellini (1987) use a reputational mechanism in their paper while maintaining the finite horizon model, the outcomes will not stay equal over all periods.

Lastly, the objectives of the monetary authority that are considered in this model could be questioned. As discussed earlier, the monetary authority influences inflation rate and also looks at output levels, which also corresponds with the Barro Gordon model. However, in their model Alesina and Tabellini (1987) also assume that both authorities include the government spending gap in their loss function. If this should be the case for the monetary authority remains questionable. Government spending does influence output level in which the monetary authority is interested. However, this already is included in the output level equation. Furthermore, the paper by Beetsma and Bovenberg (1998) does not include the government spending gap in the loss function of the monetary authority. This assumption is also often not included in other models (Dixit & Lambertini, 2003; Rogoff, 1985).

4. Disciplined policymakers by Beetsma and Bovenberg (1998)

4.1 Main contribution and background

As stated earlier, common currency areas like the European Monetary Union (EMU) have received more attention. Especially, the role of fiscal and monetary policy in such monetary unions. Many arguments in the literature investigate the downside of separate, independent fiscal authorities in a monetary union. Alesina and Tabellini (1987) investigated coordination between the fiscal and monetary authority. In contrast, Beetsma and Bovenberg (1998) look at the other side of uncoordinated fiscal policy makers and claim that the lack of coordination between fiscal authorities might keep the fiscal authorities in check. This paper thus contributes to the discussion if fiscal coordination is beneficial in a monetary union. Other than the paper by Alesina and Tabellini (1987), this paper already has a setting in the monetary union but the set-up of the model is similar. Moreover, their model has a lot of room for the role of the separate fiscal authorities which can help understand the differences between fiscal policymaking in a monetary union and in a single country.

Beetsma and Bovenberg (1998) suggest that having independent fiscal authorities is beneficial, since it decreases the influence each of these fiscal authorities has compared to the central bank. They argue that the fiscal authority could increase taxes to lower output level, which incentivizes the central bank to increase inflation. However, when there are more independent fiscal authorities, a decline in output for one of the countries has a smaller influence on the average of all countries. When all the separate fiscal authorities would cooperate, the model would function in a similar way to a model with one fiscal authority. To substantiate their argument, the authors built further on a paper by Barro and Gordon (1983) in which society sets the wage rate first and the fiscal authority sets their tax rates before the monetary authority decides on the money supply. Setting the game in this manner, is often referred to as fiscal leadership.

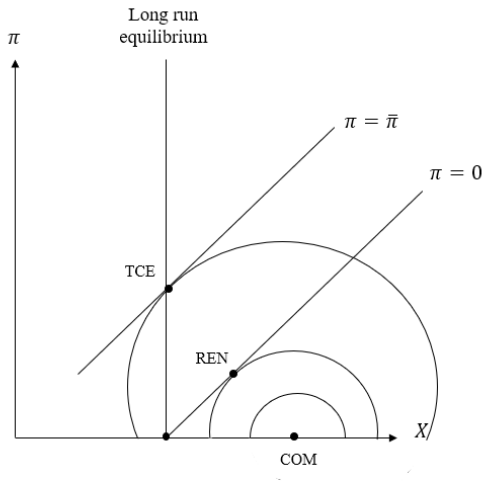

Figure 3 Barro Gordon model

Because of the fiscal leadership, this paper explicitly focuses on the way the fiscal authorities can make decisions. The central bank focusses on the output level and the inflation rate which can be illustrated by figure 3. The individual countries can raise taxes to lower output levels. Since the fiscal authorities moves first, the central bank is aware of the decrease in output

levels before making a decision while setting their inflation rate. Therefore, the central bank will be tempted to increase inflation.

4.2 Players in the model

Beetsma and Bovenberg (1998) built a model in which three players interact. Their interaction can be illustrated by figure 4. First of all, the wage setter sets the wage rate. In their paper, the authors use trade unions to set the wages for all employees. Therefore, the wages are known and set before the other two players, the fiscal and the monetary authority, react. After the wages are set, the fiscal players will determine the tax rate. Thus, the monetary authority is aware of this tax rate before making a decision on the inflation rate. Now, the monetary authority decides on the money supply which determines the inflation rate. Afterwards, the fiscal authority will be setting the governance spending in a way that balances the government budget.

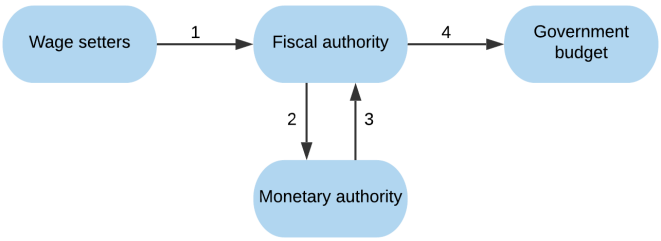

Figure 4 Interaction Beetsma and Bovenberg (1998)

The trade union fully focusses on the targeted real wage and their decision making is not affected by the unemployment rate. The trade union forms rational expectations about the inflation rate which is included in their wage bargaining. The tax rate considered in this model is a labor tax, other than the tax rate on total firm revenues which is used in the model by Alesina and Tabellini (1987). As described earlier, the central bank takes their decision after the fiscal authority. However, their decision does influence fiscal policy since it will co-determine the rate of government spending that is used to balance the government budget. When the central bank sets money supply, and thereby inflation, they do not internalize the government budget constraint. The central bank is only focused on output as well as inflation and is in general keener on inflation than the fiscal authority. In their model, the authors treat the central bank as independent, but they also stress that this is instrumental independency. Even though the central bank is independent of the fiscal authorities on paper, this does not necessarily imply that there is no way for the fiscal authority to put pressure on them. The authors refer to this phenomenon as instrument independency. For that reason, output is also included in the loss function of the central bank. Lastly, the fiscal authority faces a trade-off between output and tax rates. Higher tax rates will hurt output level but will lead to more room in the government budget constraint. The two authorities do not have to put the same

weights on output and inflation. The fiscal authority might act opportunistic in the sense that they put too little weight towards inflation. Besides the two objectives they share with the monetary authority, the fiscal authority also has a government spending objective.

The model assumes that all economies are equal in and they all produce one perfectly substitutable good. This assumption might be strong since the economies within the EMU come with a great variety (Lane, 2006). However, this assumption only makes the claim that they make harder to prove. When the economies are more identical, they will have more similar preferences, and this might coordinate fiscal policy indirectly. This claim will be further discussed in the critical reflection of this paper later on. Furthermore, the authors assume that labor is immobile which is a claim that they can substantiate as realistic. As discussed earlier, labor is mobile is across borders in the EMU. However, labor is still not very mobile because of cultural differences and differences in languages (Williams, Baláž, & Wallace, 2004).

4.3. Constraints and targets

The authors use a simple a simple function for output which is normalized to zero: $x_i = \pi - \pi^e - \tau_i$. Besides tax distortions, output can also be influenced by non-tax distortions. The authors indicate an output level that is free from any distortions by $\tilde{x}$. This level is used as the target level. When the government wants to get back from a distortionary level to a non-distortionary level, this can be done by imposing a subsidy. Besides the output target, the government has a government spending target denoted by $\tilde{g}$. This level is the part of the non-distortionary output that should be used for government spending.

The government spending is, as stated earlier restricted by a budget constraint:

$$g_i + (1 + \rho + \pi^e - \pi)d = \tau_i + \kappa\pi \qquad (9)$$

At the left side of this equation, the spending side, we find the government spending and the costs of the exogenous level of debt. These costs are determined by the level of real interest rate, ρ, and the difference between the expected and the real inflation rate. The right-hand side of the equation can be referred to as the income side of the equation which is made up of taxes and the seigniorage income. Since this model considers one central bank with more fiscal authorities, the seigniorage income will be divided equal between all these authorities. Important to note is that the fiscal authority does have to pay for debt but is not able to issue new debt. The authors use the government budget constraint to come to the government financing requirement, $\tilde{K}$. This shows what the governance needs to balance the budget and is

tied to the decision made at point (4) in figure 1. This equation includes government spending, debt servicing costs and, lastly, the implicit tax revenue denoted by $t\tilde{x}$.

$$\tilde{K} \equiv \tilde{g} + (1+p)dt\tilde{x} \tag{10}$$

Lastly, society, the fiscal and monetary authority all have separate loss functions. Therefore, the weights towards the targets do not have to be the same for all players. This loss function is also where the authors include the number of fiscal authorities. The output objective, measured ad the difference between the output level and the distortionary output level, is the average of the output of all countries in the monetary unions.

4.4 Model in practice

As explained earlier, the central bank is in charge of the inflation rate after the wage setters set their wages and the fiscal authority sets its taxes. Therefore, the central bank minimizes their loss function with the output equation. In this way, the expectations by society and the tax rates are taken into account when setting the inflation rate. This results in the central bank reaction function:

$$\pi = \left(\frac{1}{1+\alpha_{\pi M}}\right) + [\pi^e + \frac{1}{n}\sum_{i=1}^{n}(\tau_i + \tilde{x})] \tag{11}$$

The equation takes the tax level as well as the implicit taxes into account. Instead of adding these taxes cumulatively, they are included as an average for the union. When taking first order derivatives towards the tax rate, this results in $\frac{\partial \pi}{\partial \tau_i} = \left(\frac{1}{n}\right)(1+\alpha_{\pi M})^{-1}$. This shows that the influence the tax rate has on the inflation rate declines with the numbers of countries, n. Also, when the weight the monetary authority puts on inflation declines, the influence of the tax rate goes down. This makes intuitive sense. If the monetary authority only cares about inflation rates, taxes have little influence.

While the monetary authority is setting inflation, the government, and thus the fiscal authority, will minimize their loss function over the instruments they have, which are the tax rate and the government spending rate. This is done subject to the output equation and the government budget constraint. Furthermore, the fiscal authority takes the reaction function of the central bank into account.

Together, the fiscal and the monetary authority come to three policy outcomes: the seigniorage income, the tax rate and the government spending gap.

$$\kappa\pi = \left(\frac{\kappa/\alpha_{\pi M}}{1+\kappa/\alpha_{\pi M}+\gamma_n/\alpha_{gS}}\right)\tilde{K} \tag{12a}$$

$$\tau + \tilde{x} = \left(\frac{1}{1+\kappa/\alpha_{\pi M}+\gamma_n/\alpha_{gS}}\right)\widetilde{K} \quad (12b)$$

$$\tilde{g} - g = \left(\frac{\gamma_n/\alpha_{gS}}{1+\kappa/\alpha_{\pi M}+\gamma_n/\alpha_{gS}}\right)\widetilde{K} \quad (12c)$$

As becomes visible in all three equations, the outcomes all have a separate share of the government financing requirement, $\widetilde{K}$. At first glance, all these outcomes seem to be unaffected by the number of countries within a monetary union. Within these shares, the weights have different influences on the outcomes. For the seigniorage rate, the weight of the monetary authority towards inflation, $\alpha_{\pi M}$, is of importance. For the government spending gap, the weight of society towards government spending, α_{gS}, is considered. At a first glance, the number of fiscal authorities does not end up in these outcomes. However, the authors introduce the parameter γ_n, which has the following equation:

$$\gamma_n = \left(\frac{(n-1)/n+(1/n)(\alpha_{\pi F}/\alpha_{\pi M})+\alpha_{\pi M}}{1+\alpha_{\pi M}+\kappa+d/n}\right) \quad (13)$$

The parameter has a value between zero and one and expresses the degree in which the government has a spending bias. A low value, close to zero, refers to a bigger spending bias. The authors claim that this parameter can be used to describe the tax-spending mix in the case of fiscal leadership. The mix between taxes and the government spending gap can be denoted as $(\tilde{g} - g)/(\tau + \tilde{x}) = \gamma_n/\alpha_{gS}$. In other words, the part of government spending that is financed through taxes depends on the parameter γ and the weight society puts on government spending, α_{gS}. If the parameter has a value of one, this is equal to the efficiency equilibrium. However, when the value of γ becomes smaller, taxes increase and the government spending, g, increases.

4.5 A spending bias

But what brings about such a spending bias? First of all, the monetary authority does not get utility from the changes in the value of real money holdings and government debt as a result of their inflation rate. In order to indirectly internalize these values in the loss function of the central bank, the fiscal authority wants to raise taxes. By raising taxes, output goes down and the central bank is willing to raise inflation to protect unemployment levels. An increase in taxes could harm unemployment levels since employees would become more expensive for companies. The increased inflation will, in turn, benefit the fiscal authority. However, this is only of interest for the fiscal authorities when there are seigniorage benefits or when lowering

the expenses from their government debt is relevant. In other words, the only happens when benefits from the decreased costs of government debts and the seigniorage holdings do not cancel each other out. When this is not the case, the fiscal authority will have no interest in increasing the tax rate to promote inflation.

Another reason for a spending bias is a conflict between the fiscal and monetary authority about the weight that should be attached to inflation. When the fiscal authority cares less about inflation than the monetary authority does, the fiscal authority wants to promote higher inflation to make more room for government spending and output levels to decrease the value of their loss function. The central bank, in turn, attaches more value to inflation so increasing this rate hurts their loss function.

Beetsma and Bovenberg (1998) analytically show in their paper that both these effect diminish in two cases. First of all, when the weight of the monetary authority to inflation becomes very large, close to infinity, the central bank will not even try to raise inflation when tax rates increase. The central bank is no longer willing to give up the inflation target to increase unemployment levels. The other possibility is in the case of very large union. When the number of countries, n, becomes bigger, the weights of the seigniorage and the debt levels of one individual country will be averaged out to the other countries and will only be a small part of the total level. Also, this will result in beggar-thy-neighbor policies since the fiscal authorities hope that others still increase their tax rates to increase the inflation rate. They will try to reap the benefits from a higher inflation rate without decreasing their own output levels first.

The authors further shortly go into a few special cases in which the mechanism would change. The authors claim that if there is only an inflationary target for the central bank, the fiscal and monetary authority disagrees even more about the rate that would be optimal. Furthermore, they shortly refer to a case within the weight for the monetary authority towards inflation approaches infinity. In this case, the authors claim that the policy outcome would be second best; the best possibility given the government budget constraint, since there is no spending bias and no inflationary bias because the fiscal authority would know that pressuring the central bank would not work. Thus, a well designed conservative central bank with a high weight towards inflation is more beneficial than inflation rate targeting.

Because of the results above, the authors describe a larger monetary union as beneficial since the fiscal authorities will less likely increase the taxes to promote an inflationary bias by the central bank. However, because inflation is not the only objective, it is interesting to see if society benefits from an increased size of the union. Beetsma and Bovenberg (1998) use the loss function of society to look at the equilibrium welfare loss.

4.6 Critical reflection

To get to the main point of their model, Beetsma and Bovenberg (1998) do use several assumptions. The authors do not use the possibility to finance government spending through debt in their model, this could lead to similar problems as described in the critical reflection of the model by Alesina and Tabellini (1987). In the model by Beetsma and Bovenberg (1998), labor is assumed to be immobile. As discussed before, labor is indeed not very mobile across the European Union. However, this does not mean that it is immobile at all or that this cannot change over time. When including labor mobility in the model, the wage rate and unemployment levels add another dimension in the model. When one country has a very high wage rate, citizens might be willing to cross borders to improve the wage levels. Furthermore, in countries with similar wage rates but with different unemployment levels, people might cross borders to increase their chances of landing a job. Thus, assuming that labor is immobile leaves this model with a simplified choice architecture for the authorities deciding over their policy instruments. But, when looking at the outcomes of the model, the biggest difference will be visible in the loss functions of the fiscal authorities. The differences between the output and government spending outcomes will increase. However, the outcomes for all separate authorities are taken as an average when the central bank determines the inflation rate.

This also ties together with the assumption that all countries are similar. With this assumption, the weights for the separate countries are equal. However, the authors do not go into the outcomes for, for example, output levels or government spending levels. As noted earlier, the differences between different countries within the European Union are rather big. When the assumption of immobile labor supply is dropped, these differences might become bigger. What happens to the outcome and the functioning of the model when this is taken into account? Since the monetary authority considers the average output levels while deciding on the inflation rate, the decision minimizes the loss function for the central bank based on the average. However, within this average, there might be big differences between some countries with very different preferences or economic structures. Thus, while the inflation rate might be too high for some countries, it will become too low for others. Indeed, it would be the case that all countries will feel like that their policies will have no, or little, influence on the policy of the central bank. However, it will still be questionable if this is best for the European Monetary Union as a whole. As mentioned before, the fiscal policies of the separate countries do spill-over to other countries. Therefore, considering if more than one fiscal authority is best should be a trade-off between those two things. So, on one hand the losses to the European union as a

whole as a result of different and maybe contradicting fiscal policies. And, on the other hand, possible lower inflation levels and lower tax levels as a result of the decreased influence of every fiscal authority on the loss function of the monetary authority.

5. Changing the rules and the setting of the game

Previous chapters have discussed two important paper about fiscal coordination. A visual comparison of these paper scan be found in table 1 below. Alesina and Tabellini (1987) wrote about coordination between the fiscal and the monetary authority, which corresponds with arrow A in table 1. Their model is a one-country model, so the fiscal authorities can be described as 'coordinated'. They show that moving to an equilibrium where the central bank has a binding commitment towards an inflation target is not always optimal. In order to get to this outcome, they compare the loss functions of the three players in the binding commitment and the time consistent equilibrium. The authors compare a situation in which the fiscal and monetary authority do not cooperate with a scenario in which they do cooperate. The latter is accomplished by giving both authorities equal weight towards the three policy objectives. Beetsma and Bovenberg (1998) look at the effects of a monetary union with one monetary authority and several independent fiscal authorities. They claim that coordination amongst all fiscal authorities will not be beneficial compared to an uncoordinated situation since this would enhance the inflationary bias. To show this, they compare two settings in the time consistent equilibrium in which the fiscal authorities are coordinated and non-coordinated. This comparison is marked by arrow B in the table below. Furthermore, they show the effect of a big or a small monetary union by increasing the number of fiscal authorities.

Both papers have quite some similarities. The models both have a game theoretic approach and the game consists of three players where the wage setters. In the model of Alesina and Tabellini (1987), the game is played simultaneously. In the paper by Beetsma and Bovenberg (1998), there is a sequential game where the fiscal authority decides on the tax rate before the monetary authority makes their decision. In both cases, the central bank not only cares about the inflation rate but also considers the level of output. However, in the model by Alesina and Tabellini (1987) the monetary authority also takes the deviation of government spending from its' target into account. Furthermore, the government budget constraint differs. The government budget constraint in the paper by Alesina and Tabellini (1987) only consists of the tax rate, the inflation rate and public spending, The government budget constraint in the paper by Beetsma and Bovenberg (1998), on the other hand, also includes the debt ratio of the

government. In both papers, the fiscal authority cannot use debt to finance government expenditures. Thus, in both papers, this takes away a source of time inconsistency for the fiscal authority.

In this section, two possible extensions of the models described above are discussed. The comparisons between different institutional arrangements made by the authors in the paper are denoted with the black arrows in table 1. Arrow A stands for the paper by Alesina and Tabellini (1987) whereas arrow B stands for the Beetsma and Bovenberg (1998) paper. This section will explain what happens if the model by Alesina and Tabellini (1987) will be taken to an environment with several uncoordinated fiscal authorities, denoted by the dotted arrows in table 1. Secondly, this section will go into the game theoretic setting of the Beetsma and Bovenberg (1998) paper and will investigate how the results changes when the rules of the game change and fiscal leadership disappears.

Fiscal authorities → Equilibrium ↓	Coordinated	Non-coordinated
Commitment		
Time-consistent	A B	

Table 1 Comparison of the papers by Alesina and Tabellini (1987) and Beetsma and Bovenberg (1998)

5.1 Simultaneous games in Beetsma and Bovenberg (1998)

As denoted earlier, both papers have their foundations in a game theoretic model with three players. These three players are represented by fiscal authorities, the monetary authority and a third agent that is represented by the wage's setters or society. However, the order in which these three players make their decisions differ in the two models. For the purpose of this analysis, the focus is on the monetary and the fiscal authority. In the paper by Alesina and Tabellini (1987), the three authorities make their decisions simultaneously while knowing the response functions of the other players. However, Beetsma and Bovenberg (1998) have developed a model with fiscal leadership. The fiscal authority will set the tax rate first while they already know at what level the wages are set by the wage setters. Thereafter, the monetary authority will set the inflation rate after which the fiscal authority determines the rate of government spending that is needed to balance the budget. This leaves the fiscal authority with more power relative to a simultaneous game. Once the tax rate is set, the monetary authority considers this tax rate in their responses. However, it is questionable if the assumption of fiscal

leadership really holds within a monetary union and the European Union in specific. Furthermore, some have argued that fiscal leadership will only improve the overall welfare when the shocks are highly correlated (Dixit & Lambertini, 2001). Since shocks are not always correlated within the European Union, it might not be optimal to turn to fiscal leadership. Therefore, it would be interesting to think about what happens to the model of Beetsma and Bovenberg (1998) when the assumption of fiscal leadership would be relaxed. Because of the focus of this paper, the wage setters will still set their wages before both authorities will make a decision.

First of all, the power of the fiscal authority will be decreasing. In the original model, they did consider the responses of the other players while making their decision. However, under the assumption of fiscal leadership, the fiscal authority only cares about the response of the monetary authority at the taxation rate they have selected. Thus, with fiscal leadership, the outcome of the game becomes more dependent on the choice made by the first mover. This leaves the fiscal authority with some power over the decision the monetary authority is facing. Consequently, the monetary authority will be more likely to end up choosing a higher level of inflation to get output closer to their desired level to minimize their losses from a big output gap. However, this mechanism will change when the fiscal authority cannot set taxes, and by doing so influence output, before the monetary authority can make their decision on inflation.

The difference that becomes visible after taking a way the first mover advantage from the fiscal authority is similar as the comparison Alesina and Tabellini (1987) make between a monetary authority with a credible commitment, which has similar implications as a first-mover advantage, and a discretionary regime. By taking a way this advantage, the policy outcome is less close to the preferences of the fiscal authority and will thus be less beneficial for them. The tax rate goes down a bit, because increasing the tax rate to get the monetary authority to increase inflation will become less effective. The monetary authority will consider the loss function, and hence the best response function, while making a decision. This implies that the distance between the equilibrium outcome in a situation with fiscal leadership and a situation with simultaneous decision making ultimately depends on the weights the fiscal authority puts on all three objectives. When the fiscal authority acts opportunistically and put very little weight on inflation, the outcome will be relatively close to the outcome under fiscal leadership. The reason for this is that the monetary authority knows that the fiscal authority will still be willing to increase taxes a lot to try to convince the monetary authority to inflate.

5.2 Uncoordinated fiscal coordination in Alesina and Tabellini (1987)

In this section, the extension to the paper by Alesina and Tabellini (1987) is discussed. In their paper, the policies are determined by one fiscal and one monetary authority. This is different from the Beetsma and Bovenberg (1998) paper where every country in a monetary union has a separate fiscal authority. The paper by Alesina and Tabellini (1987) describes that giving the central bank a binding commitment will not always be a Pareto optimal solution. However, it remains unclear if their results would hold in a situation of a monetary union with more than one fiscal authority and one central bank. Therefore, this thesis extends their model to a model with two fiscal authorities which are uncoordinated, as denoted with the dotted arrows in table 1. The original situation in the Alesina and Tabellini (1987) model can be compared to the setting with coordination amongst fiscal policymakers in Beetsma and Bovenberg (1998). Beetsma and Bovenberg (1998) claim that the outcome of a setting with coordinated fiscal policies is the same as a model with one fiscal authority. To look at this extension, the setting of the game by Alesina and Tabellini (1987) remains the same as the original setting but will only be altered to make room for more fiscal authorities. This means that the players in the model will still move simultaneously and all players still have the same policy instruments.

The mechanism here could still operate similar to the mechanism in the original model. A different reaction of the monetary authority to changes in government spending and output levels can be expected. To look at what happens in case of more than one fiscal authority, the model will be extended towards a two-country model. Within this model, there is only one central bank that determines the inflation rate, just like in the original model. However, each fiscal authority can set their own tax rates and influence output by doing so. The two countries have a similar economy in the sense that they have the same preferences towards output, government spending and inflation. Moreover, the size and state of the economy is also equal in both countries. This assumption matches the assumption that has been made by the monetary union model by Beetsma and Bovenberg (1998). The central bank treats output as the sum of the two countries. The same goes for the government spending gap.

The biggest difference that will incur is the change in the reaction to fiscal policy by the monetary authority. As described before, Beetsma and Bovenberg (1998) show that compared to one fiscal authority or several coordinated fiscal authorities, the output on a one country level will affect the monetary authority less. The reason for this is that the monetary authority looks at the average deviation of the output level from the non-distortionary target. In the Alesina and Tabellini (1987) paper, the central bank does not only look at output and inflation but also have

an interest in the levels of government spending. However, while Beetsma and Bovenberg (1998) look at the average output levels and government spending gap, this model is extended with the summation of the two countries since we could assume that the monetary authority looks at the total outcomes within the union. To compare the scenario, this model assumes that the monetary authority will stay interested in the gap between government spending and its target, just like the original model by Alesina and Tabellini (1987). By making this assumption, both authorities wish to keep public expenditure constant over time.

Before looking at the model itself, the intuitive reasons for the central bank to behave differently when more fiscal authorities come into play can be considered. First of all, the central bank looks at the total government spending gap and output level. If the output level drops for one of the two countries, the percentage change in the total output is smaller than it was in the scenario of a setting in which there is one fiscal authority and one monetary authority. Furthermore, even though the weights the fiscal authorities have towards their different goals remain equal, the output level and government spending gap they are looking at are only those of their own country. In contrast, the monetary authority oversees the whole and is interested in the total amounts. Since the separate countries only look at their own well-being, they might be tempted to benefit from problems in other countries. They might expect the inflation rate to go up because of the low output levels or the big government spending gap in the other country. As a result, the domestic country might be willing to lower their tax rate if they feel like they would benefit enough from the higher inflation rate caused by the situation in the other country. This mechanism could also work in the other direction. If a country knows that the government spending gap is very small in the other country or that their output is very high, they will know that inflation rates will be lower and will make their decision with this knowledge in mind.

As described earlier, the fiscal authorities still will only look at the outcomes for their own country. Therefore, their loss function will remain relatively similar. In this equation, i stands for the separate fiscal authorities.

$$V_i^{FA} = \left(\frac{1}{2}\right) \sum_{t=0}^{T} \theta^t [\pi_t^2 + \delta_1 x_i^2 + \delta_2 \left(g_{t,i} - \bar{g}\right)^2] \tag{14}$$

In contrast, the central bank does experience some changes in its' loss function. As stated earlier, the central bank will consider the sum of the separate authorities. X is equal to the sum of x_1 and x_2. Furthermore, G stands for the sum of the different government spending levels g_1 and g_2. Lastly, $\bar{G}$ is computed by multiplying $\bar{g}$ by two since both countries have an equal government spending goal because of the similar economies.

$$V^{CB} = \left(\frac{1}{2}\right)\sum_{t=0}^{T}\beta^{t}[\pi_t^2 + \mu_1 X_1^2 + \mu_2(G_t - \bar{G})^2] \quad (15)$$

Important to note, the government spending equation and the output equations for both countries remain the same as the original ones[1].

5.2.1. A discretionary regime

First, the outcomes under a discretionary regime are described. Just like the original model, the loss function of the central bank and the fiscal authority are differentiated to obtain their first order conditions. The first order condition of the fiscal authorities will remain since the loss function has not changed[2]. However, the first order condition for the monetary authority has been altered because of the increased number in fiscal authorities that are included in the loss function[3]. In combination with the output equation and the government budget constrained this will yield the following policy outcomes. The full derivation of these policy outcomes can be found in Appendix 2.

$$x_i = -(\delta_2/\alpha\delta_1)(\bar{g} - g_i) \quad (16a)$$

$$X = -(\delta_2/\alpha\delta_1)(\bar{G} - G_t) \quad (16b)$$

$$\pi = \frac{\mu_1\delta_2 + \mu_2\delta_1}{\delta_1}(\bar{G} - G_t) \quad (16c)$$

$$(\bar{g} - g_1) = \frac{\alpha^2\delta_1(\bar{g} + \upsilon_i)}{\left(1+\frac{g_2}{g_1}\right)[\delta_2(1+\alpha^2\mu_1)+\alpha^2\mu_2\delta_1]} \quad (16d)$$

$$(\bar{G} - G_t) = \frac{\alpha^2\delta_1(\bar{g} + \upsilon_i)}{[\delta_2(1+\alpha^2\mu_1)+\alpha^2\mu_2\delta_1]} \quad (16e)$$

From the equations above, there is one thing that immediately stands out[4]. Namely, that there is simply more equation than in the original situation. The reason for this is straightforward. Because of the extension to a two-country model, both output as well as the government spending gap have an outcome for the individual country as well as an outcome for the union as a whole. Looking at the output levels, denoted by x_i for the separate countries and X for the

[1] The government spending equation is equal to $g_t = \tau_t + \pi_t$ and the output equation equal to $x_t = \alpha(\pi_t - \pi_t^e - \tau_t - \upsilon)$

[2] First order condition of the fiscal authority: $-\alpha\delta_1 x + \delta_2(g - \bar{g}) = 0$

[3] First order condition for the monetary authority with more than one fiscal authority:

$$\pi + \frac{\alpha\mu_1 x}{n} + \frac{\mu_2(g - \bar{g})}{n} = 0$$

[4] When computing this model, the original equations by Alesina and Tabellini (1987) were rebuilt. When rebuilding, a difference between one of the equations and the original equation by the authors was found. This is the government spending equation. The fully derivation of this outcome can be found in appendix one. For the purpose of this section, the outcomes are compared with the outcomes that were found after rebuilding the model.

union as a whole, the outcomes are the same as they were in the original model. The output level still is determined by the weights the government puts toward output and government spending. Thus, the relationship between the output level and the government spending gap remains unchanged. Important to note is, that when government spending in the new situation is different from the old one, this still has an influence on the output level. The output level for the entire union is a simple summation of the outcome for the two countries involved.

The inflation rate, π, also remains equal to the equation before with one important difference. Instead of looking at the output gap for one country, the inflation rate is dependent on the sum of the output gap of the two countries. This implies that the inflation rate between the original situation and the new situation will remain unchanged when both countries have an equal output gap. However, when the output gap for the two countries are not equal, this makes a difference. This could be illustrated by a simple example. Country, one has a very small output gap. Under the previous arrangements, this would imply that inflation levels would be low. However, in the new situation, when country two has a relatively high output gap, this leads to a higher sum of the output gaps for both authorities. This results in an inflation rate that is too high for country one and too low for country two.

The biggest change is visible in the government spending gap. Even though the government spending gap in summation has a similar equation as the outcome in the original model, the equation for the separate countries does show a difference. Besides the numerator that has been in the formula before, a new component is added here. The numerator, as a whole, is also multiplied by the ratio of the government spending of the other country compared to the domestic country. The equation above is the example of this outcome for country one. It becomes clear, that in the case that the government spending ratio is bigger in the other country compared to the domestic spending ratio, a bigger term is added to the numerator. This, in turn, implies that the numerator becomes larger and the value of the fraction becomes smaller. In other words, when the other countries have a relatively high level of government spending, the gap for the domestic country becomes smaller. A way to look at this is, when the government spending is very large in the other country, it will be easier to get government spending close to the target in the domestic country. The reason for this is that the monetary authority considers the situation in the union as a whole, which means that the domestic country can benefit from higher levels of inflation caused by the spending gap of the other country. However, when looking at the government spending gap as a whole, which is also the equation that the monetary authority will keep in mind while setting the inflation rate, the government spending levels are equal.

5.2.2. A commitment regime

In the commitment regime, the monetary authority will, just like in the original model, be able to impose a binding commitment on the inflation rate and will not deviate from this. Therefore, all players will take this zero-inflation rate into account. The fiscal authority will remain to have the same first-order condition as shown before. However, the first-order condition of the monetary authority will change because of the different circumstances[5]. When taking, again, the output equation and the government budget constraint into account, this yields the outcomes below. The full derivation of these equations can be found in Appendix 3.

$$x_i = -(\delta_2/\alpha\delta_1)(\bar{g} - g_i) \tag{17a}$$

$$X = -(\delta_2/\alpha\delta_1)(\bar{G} - G_t) \tag{17b}$$

$$\pi = \mu_2(\bar{G} - G) \tag{17c}$$

$$(\bar{g} - g_1) = \frac{(\bar{g}+v_i)}{\mu_2(g_2/g_1+1)} \tag{17d}$$

$$(\bar{G} - G_t) = \frac{(\bar{g}+v_i)}{\mu_2} \tag{17e}$$

In these output equations, not a lot has changed since the output equation and inflation equation still looks relatively similar to the outcomes of the original model. However, here also the relative government spending levels come into the equation in the equation for the government spending gap in the separate countries. The same mechanism applies as the mechanism in the outcomes under a discretionary regime. In other words, when government spending becomes higher in the other country, the government spending gap for the domestic country becomes smaller.

5.2.3 Comparing a discretionary to a commitment regime

To recall, the original model of Alesina and Tabellini (1987) yields the outcome that under a commitment regime inflation is lower, output is lower, tax rates are higher and government spending rates are lower. Since output and inflation outcomes in the model with two fiscal authorities are similar to the equations in the original model, inflation and output are still lower under a commitment regime than under a discretionary regime. The same goes for the total government spending gap. An important difference between the two outcomes is that

5 First order condition of the monetary authority under a commitment regime: $\pi + \mu_2([g_1 + g_2] - \bar{G}) = 0$

in the government spending equation for the individual countries has changed and the ratio of own government spending with respect to the government spending levels of the other country enters the equation. However, this still leads to government spending, which is lower in the commitment regime, but the distance between the two scenarios depends on which country has the higher government spending ratio. If the domestic country has a higher government spending ratio, the numerator becomes smaller in both cases, but this difference is bigger in the discretionary regime. Thus, if the domestic government spending level is higher than the foreign government spending level, the gap between the discretionary and the commitment regime becomes smaller. Naturally, this gap becomes wider when the domestic government spending level is lower than the foreign government spending level.

However, the difference is rather small, when we compare the original model that is altered to a model with more than one fiscal authority. Even though the government spending levels on which the monetary authority bases its inflation rate becomes bigger because of the two countries together, the government spending levels are always considered in relation to the target level. However, in the loss function of the monetary authority, the output level stands on its own and this implies that the monetary authority gets hit harder with a change in output levels. Thus, moving the model by Alesina and Tabellini (1987) to a two-country model does not yield similar outcomes to the outcomes by the model by Beetsma and Bovenberg (1998) model. The differences between these two models are the targets for the monetary authority, the rules of the game in both models and the way the different fiscal authorities are included in the model. At a first glance, the way the authorities are put into the model is the biggest difference in the outcome. In their model, Beetsma and Bovenberg (1998) describe that the increasing number of countries, n, decreases the influence each individual country has on the total output equation. This is similar to what is found in the results above, since each country has a smaller relative share of the output of government spending gap that the monetary authority bases its' inflation rate on. However, this does not come back in the ultimate output equations the new model has produced. Maybe, this has to do with the fiscal leadership setting in the Beetsma and Bovenberg (1998) which is missing in the new model. With fiscal leadership, the fiscal authority moves first and takes the reaction function of the monetary authority into account. However, when there are more fiscal authorities, they also have to consider the response of the other countries. This might lead to countries backing out of the high tax rate, following a beggar-thy-neighbor policy. Lastly, the specification that the monetary authority also cares about government spending presumably does not have any influence on the outcome.

6. Conclusion and discussion

This thesis has gone into debt about the mechanisms of the papers by Alesina and Tabellini (1987) and Beetsma and Bovenberg (1998). Both papers go into policy coordination in a three-player game theoretic model. However, Beetsma and Bovenberg (1998) consider coordination amongst fiscal authorities in a model with fiscal leadership. The paper by Alesina and Tabellini (1987), on the other hand, discusses coordination between the fiscal and monetary authority in a simultaneous game within a one-country model.

These differences have been used to extend these models and test how the outcomes of the models would change when changing the setting of the games. With the paper by Beetsma and Bovenberg (1998), the simultaneous movements of the fiscal and monetary authority are introduced. Because of that change in the rules of the game, part of the power from the fiscal authority disappears, possibly leading to lower tax rates and lower inflation rate. Furthermore, the model by Alesina and Tabellini (1987) was altered from a one-country model into a two-country model to represent a monetary union with several fiscal authorities and only one monetary authority. However, a big part of the changes did come back in the differences in the policy outcomes. It seems that only the size of the government spending gap of the individual countries would change while leaving the equations for the other outcomes equal. This might be an interesting result to further delve into, since the government spending gap, which would be connected to debt levels, is of concern both in the theory as well as into practice. However, it seems that the results found by Beetsma and Bovenberg (1998), which indicated that more fiscal authorities will not become as visible in the setting of the paper by Alesina and Tabellini (1987). This implies that this thesis cannot substantiate the positive theory of uncoordinated fiscal authorities. Thus, it does not seem that uncoordinated fiscal authorities are beneficial for lowering the inflation levels. However, this thesis does further stress the importance of the rules of the game. A setting with fiscal leadership promotes the power of the individual authorities and might strongly influence the outcomes of the fiscal coordination trade-off.

However, these results have still room for improvement. First of all, as denoted earlier in the discussion of the separate models, the government cannot issue new debt in both models as well as in the new model. This makes an important source of time inconsistency of the fiscal authority go away and could, therefore, possibly, influence the outcomes. Further research could further extend the models discussed here to include deficits to get closer to reality. Also, as discussed before, the extend model departing from the model by Alesina and Tabellini (1987) did not support the findings of the model by Beetsma and Bovenberg (1998). More research is

needed to further discuss the value of both ways to model a monetary union and possibly built further on these models to more accurately capture the effects of monetary unification on fiscal policymaking.

Lastly, the thesis did not go into all the possible aspects of the story about fiscal and monetary coordination. The models did assume similarity across economies which creates more distance between the models and the real-life situation and decreases the complexity of the trade-off between rules and discretion in policy making. It would be interesting to involve more of the different political and cultural viewing points into this analysis. For example, the extended model did not distinguish between different weights for both fiscal authorities. However, it could be the case that these weights are connected to the culture or political background of the countries. Therefore, the model could be extended further by trying to incorporate such factors into a model. A good starting point here would be trying to loosen the assumption of having similar economies in a monetary union.

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8. Appendices

Appendix 1: Derivation of the original model by Alesina and Tabellini (1987)

When deriving the model by Alesina and Tabellini (1987) again to try and expand this model, the outcome did not match completely with what the authors has claimed to be the outcome. When describing the model in chapter 4, the outcomes in the original paper are used. However, when comparing their model with the expanded model of this thesis, the outcome that was found by rederiving the derivation in the paper are used.

Discretionary regime

First order conditions:

Central bank: $\pi + \mu_1 \alpha x + \mu_2(g - \bar{g}) = 0$

Fiscal authority: $-\alpha\delta_1 x_i + \delta_2(g_i - \bar{g}) = 0$

The output level is determined by the fiscal authority and thus the outcome is derived from the first order condition of the fiscal authority.

$$-\alpha\delta_1 x + \delta_2(g - \bar{g}) = 0$$
$$\alpha\delta_1 x + \delta_2(\bar{g} - g) = 0$$
$$\alpha\delta_1 x = -\delta_2(\bar{g} - g)$$
$$x = -(\delta_2/\alpha\delta_1)(\bar{g} - g)$$

This outcome complies with the outcome shown in the paper by Alesina and Tabellini (1987).

The level of inflation is determined by the central bank, so this outcome will come from the first order condition of the central bank.

$$\pi + \mu_1 \alpha x + \mu_2(g - \bar{g}) = 0$$
$$\pi = -\mu_1 \alpha x + \mu_2(\bar{g} - g)$$
$$\pi = -\mu_1 \alpha[-(\delta_2/\alpha\delta_1)(\bar{g} - g)] + \mu_2(\bar{g} - g)$$
$$\pi = \frac{\mu_1 \delta_2}{\delta_1}(\bar{g} - g) + \mu_2(\bar{g} - g)$$
$$\pi = \left[\frac{\mu_1 \delta_2}{\delta_1} + \mu_2\right](\bar{g} - g)$$
$$\pi = \left[\frac{\mu_1 \delta_2 + \mu_2 \delta_1}{\delta_1}\right](\bar{g} - g)$$

This outcome is also equal to the Alesina and Tabellini (1987) outcome.

To get to the last policy outcome, the authors use the two outcomes above, as well as the government budget constraint and the output equation.

$$g_t = \tau_t + \pi_t$$

$$\tau_t = \bar{g} - \pi_t$$

$$x_t = \alpha(\pi_t - \pi_t^e - \tau_t - \upsilon)$$

With rational expectations this will change into:

$$x_t = \alpha(-\tau_t - \upsilon)$$

Putting the tax rate into this equation yields:

$$x_t = \alpha(-(\bar{g} - \pi_t) - \upsilon)$$

$$x_t = \alpha(-\bar{g} + \pi_t - \upsilon)$$

To balance the budget, the equation above will have to be equal to the outcome of the output in equilibrium.

$$-(\delta_2/\alpha\delta_1)(\bar{g} - g) = \alpha(-\bar{g} + \pi_t - \upsilon)$$

Furthermore, the inflation rate has already been determined above. This outcome will be entered into this equation as well.

$$-(\delta_2/\alpha\delta_1)(\bar{g} - g) = \alpha(-\bar{g} + \left[\frac{\mu_1\delta_2 + \mu_2\delta_1}{\delta_1}\right](\bar{g} - g) - \upsilon)$$

$$\frac{(\delta_2/\alpha\delta_1)(\bar{g} - g)}{\alpha} = \bar{g} + \upsilon - \left[\frac{\mu_1\delta_2 + \mu_2\delta_1}{\delta_1}(\bar{g} - g)\right]$$

$$\frac{(\delta_2/\alpha\delta_1)}{\alpha} = \frac{\bar{g} + \upsilon}{(\bar{g} - g)} - \left[\frac{\mu_1\delta_2 + \mu_2\delta_1}{\delta_1}\right]$$

$$\frac{\bar{g} + \upsilon}{(\bar{g} - g)} = \frac{(\delta_2/\alpha\delta_1)}{\alpha} + \left[\frac{\mu_1\delta_2 + \mu_2\delta_1}{\delta_1}\right]$$

$$\frac{\bar{g} + \upsilon}{(\bar{g} - g)} = \frac{\delta_2}{\alpha^2\delta_1} + \left[\frac{\mu_1\delta_2 + \mu_2\delta_1}{\delta_1}\right]$$

$$\frac{\bar{g} + \upsilon}{(\bar{g} - g)} = \frac{\delta_2}{\alpha^2\delta_1} + \left[\frac{\alpha^2(\mu_1\delta_2 + \mu_2\delta_1)}{\alpha^2\delta_1}\right]$$

$$\frac{\alpha^2\delta_1(\bar{g} + \upsilon)}{(\bar{g} - g)} = \delta_2 + \alpha^2\mu_1\delta_2 + \alpha^2\mu_2\delta_1$$

$$\frac{\alpha^2\delta_1(\bar{g} + \upsilon)}{(\bar{g} - g)} = \delta_2(1 + \alpha^2\mu_1) + \alpha^2\mu_2\delta_1$$

$$(\bar{g} - g) = \frac{\alpha^2\delta_1(\bar{g} + \upsilon)}{\delta_2(1 + \alpha^2\mu_1) + \alpha^2\mu_2\delta_1}$$

This outcome differs from the original outcome by the paper, since the paper gets to the outcome of: $(\bar{g} - g) = \frac{\alpha^2\delta_1(\bar{g}+\upsilon)}{\delta_2(1+\alpha^2\mu_1)+\alpha^2\delta_1(\mathbf{1}+\boldsymbol{\mu_2})}$. Comparing these outcomes, there is an extra term in the denominator on the left-hand side, which comes to $\alpha^2\delta_1$.

Binding commitment regime

Within the commitment regime, the first order condition of the central bank alters to a situation in which the central bank knows that they can commit to a certain inflation rate before the fiscal authority makes a move.

CB: $\pi + \mu_2(g - \bar{g}) = 0$

FA: $-\alpha\delta_1 x_i + \delta_2(g_i - \bar{g}) = 0$

The output equation is still determined by the fiscal authority. Since this first order condition did not change, the outcome will still come to:

$$x = -(\delta_2/\alpha\delta_1)(\bar{g} - g)$$

This outcome complies with the outcome shown in the paper by Alesina and Tabellini (1987).

The level of inflation is determined by the central bank, so this outcome will come from the first order condition of the central bank. Because the output level is no longer in the first order condition, the inflation level comes to:

$$\pi + \mu_2(g - \bar{g}) = 0$$

$$\pi = \mu_2(\bar{g} - g)$$

This outcome is also equal to the Alesina and Tabellini (1987) outcome.

The output equation and the government budget constraint still are combined in the same way, getting to:

$$x_t = \alpha(-\bar{g} + \pi_t - \upsilon)$$

To balance the budget, the equation above will have to be equal to the outcome of the output in equilibrium.

$$-(\delta_2/\alpha\delta_1)(\bar{g} - g) = \alpha(-\bar{g} + \pi_t - \upsilon)$$

Furthermore, the inflation rate has already been determined above. This outcome will be entered into this equation as well.

$$-(\delta_2/\alpha\delta_1)(\bar{g} - g) = \alpha(-\bar{g} + \mu_2(\bar{g} - g) - \upsilon)$$

$$\frac{(\delta_2/\alpha\delta_1)(\bar{g} - g)}{\alpha} = \bar{g} + \upsilon - [\mu_2(\bar{g} - g)]$$

$$\frac{(\delta_2/\alpha\delta_1)}{\alpha} = \frac{\bar{g} + \upsilon}{(\bar{g} - g)} - \mu_2$$

$$\frac{\bar{g}+v}{(\bar{g}-g)} = \frac{(\delta_2/\alpha\delta_1)}{\alpha} + \mu_2$$

$$\frac{\bar{g}+v}{(\bar{g}-g)} = \frac{\delta_2}{\alpha^2\delta_1} + \mu_2$$

$$\frac{\bar{g}+v}{(\bar{g}-g)} = \frac{\delta_2}{\alpha^2\delta_1} + \left[\frac{\alpha^2\delta_1\mu_2}{\alpha^2\delta_1}\right]$$

$$\frac{\alpha^2\delta_1(\bar{g}+v)}{(\bar{g}-g)} = \delta_2 + \alpha^2\mu_2\delta_1$$

$$(\bar{g}-g) = \frac{\alpha^2\delta_1(\bar{g}+v)}{\delta_2 + \alpha^2\mu_2\delta_1}$$

This outcome differs from the original outcome by the paper, since the paper gets to the outcome of:

$(\bar{g}-g) = \frac{\alpha^2\delta_1(\bar{g}+v)}{\delta_2+\alpha^2\delta_1(1+\mu_2)}$. Comparing these outcomes, there is an extra term in the denominator on the left-hand side, which comes to $\alpha^2\delta_1$.

Appendix 2: Derivation of the policy outcomes of a discretionary regime with two fiscal authorities

To get to the derivation, the first order conditions of the central bank and the fiscal authorities are used:

CB: $\pi + \mu_1\alpha(x_1 + x_2) + \mu_2([g_1 + g_2] - \bar{G}) = 0$

FA: $-\alpha\delta_1 x_i + \delta_2(g_i - \bar{g}) = 0$

Since the fiscal authority determines the output level, the derivation of the output level is based upon the first order condition of the fiscal authority. This yields equation 16a:

$$-\alpha\delta_1 x_i + \delta_2(g_i - \bar{g}) = 0$$

$$\alpha\delta_1 x_i + \delta_2(\bar{g} - g_i) = 0$$

$$\alpha\delta_1 x_i = -\delta_2(\bar{g} - g_i)$$

$$x_i = -(\delta_2/\alpha\delta_1)(\bar{g} - g_i)$$

X is built on the two separate output levels which comes to equation 16b:

$$X = -(\delta_2/\alpha\delta_1)(\bar{g} - g_1) + -(\delta_2/\alpha\delta_1)(\bar{g} - g_2)$$

$$X = \frac{-\delta_2(\bar{g} - g_1) + -\delta_2(\bar{g} - g_2)}{\alpha\delta_1}$$

$$X = \frac{-\delta_2(\bar{g} - g_1 + \bar{g} - g_2)}{\alpha\delta_1}$$

$$X = -(\delta_2/\alpha\delta_1)(\bar{G} - G_t)$$

The level of inflation is determined by the central bank. Therefore, this policy outcome is determined by the central bank's loss function together with the sum of output, X. This comes to equation 16c:

$$\pi + \mu_1\alpha(x_1 + x_2) + \mu_2([g_1 + g_2] - \bar{G}) = 0$$

$$\pi = -\mu_1\alpha(X) + \mu_2(\bar{G} - [g_1 + g_2])$$

$$\pi = \frac{-\mu_1\alpha(-\delta_2(\bar{G} - G_t))}{\alpha\delta_1} + \mu_2(\bar{G} - G)$$

$$\pi = \frac{\mu_1\alpha\delta_2(\bar{G} - G_t)}{\alpha\delta_1} + \mu_2(\bar{G} - G)$$

$$\pi = \frac{\mu_1\delta_2}{\delta_1}(\bar{G} - G_t) + \mu_2(\bar{G} - G)$$

$$\pi = \frac{\mu_1\delta_2 + \mu_2\delta_1}{\delta_1}(\bar{G} - G_t)$$

Since we have the inflation and output equation now, these two can be used to get to the government spending gap. In order to do so, the government spending equation and country output equation are needed:

$$g_{i,t} = \tau_{i,t} + \pi_t$$

$$\tau_{i,t} = \bar{g} - \pi_t$$

$$x_{i,t} = \alpha(\pi_t - \pi_t^e - \tau_{i,t} - v_i)$$

With rational expectations this will change into:

$$x_t = \alpha(-\tau_{i,t} - v_i)$$

Putting the tax rate into this equation yields:

$$x_{i,t} = \alpha(-(\bar{g} - \pi_t) - v_i)$$

$$x_t = \alpha(-\bar{g} + \pi_t - v_i)$$

To balance the budget, the equation above will have to be equal to the outcome of the output in equilibrium.

$$-(\delta_2/\alpha\delta_1)(\bar{g} - g_i) = \alpha(-\bar{g} + \pi_t - v_i)$$

Furthermore, the inflation rate has already been determined above. This outcome will be entered into this equation as well to get to outcome 16d:.

$$-(\delta_2/\alpha\delta_1)(\bar{g} - g_i) = \alpha(-\bar{g} - v_i + \frac{\mu_1\delta_2 + \mu_2\delta_1}{\delta_1}(\bar{G} - G_t))$$

$$\frac{(\delta_2/\alpha\delta_1)(\bar{g} - g_i)}{\alpha} = \bar{g} + v_i - \left[\frac{\mu_1\delta_2 + \mu_2\delta_1}{\delta_1}(\bar{G} - G_t)\right]$$

$$\frac{(\delta_2/\alpha\delta_1)}{\alpha} = \frac{\bar{g} + v_i}{(\bar{g} - g_1)} - \left[\frac{\mu_1\delta_2 + \mu_2\delta_1}{\delta_1}\left(\frac{g_2}{g_1} + 1\right)\right]$$

$$\frac{\bar{g}+v_i}{(\bar{g}-g_1)}=\frac{(\delta_2/\alpha\delta_1)}{\alpha}+\left[\frac{\mu_1\delta_2+\mu_2\delta_1}{\delta_1}\left(\frac{g_2}{g_1}+1\right)\right]$$

$$\frac{\bar{g}+v_i}{(\bar{g}-g_1)}=\frac{\delta_2}{\alpha^2\delta_1}+\left[\frac{(\mu_1\delta_2+\mu_2\delta_1)*\left(\frac{g_2}{g_1}+1\right)}{\delta_1}\right]$$

$$\frac{\bar{g}+v_i}{(\bar{g}-g_1)}=\frac{\delta_2}{\alpha^2\delta_1}+\left[\frac{\alpha^2(\mu_1\delta_2+\mu_2\delta_1)*\left(\frac{g_2}{g_1}+1\right)}{\alpha^2\delta_1}\right]$$

$$\frac{\bar{g}+v_i}{(\bar{g}-g_1)}=\frac{\delta_2+\left[\alpha^2(\mu_1\delta_2+\mu_2\delta_1)*\left(\frac{g_2}{g_1}+1\right)\right]}{\alpha^2\delta_1}$$

$$\frac{\alpha^2\delta_1(\bar{g}+v_i)}{(\bar{g}-g_1)}=\delta_2+\left[\alpha^2(\mu_1\delta_2+\mu_2\delta_1)*\left(\frac{g_2}{g_1}+1\right)\right]$$

$$(\bar{g}-g_1)=\frac{\alpha^2\delta_1(\bar{g}+v_i)}{\delta_2(1+\alpha^2\mu_1)+\alpha^2\mu_2\delta_1+\frac{g_2}{g_1}[\delta_2(1+\alpha^2\mu_1)+\alpha^2\mu_2\delta_1]}$$

$$(\bar{g}-g_1)=\frac{\alpha^2\delta_1(\bar{g}+v_i)}{\left(1+\frac{g_2}{g_1}\right)[\delta_2(1+\alpha^2\mu_1)+\alpha^2\mu_2\delta_1]}$$

When going back to $\bar{G}-G_t$, the outcomes for the two countries are taken together for outcome 16e:

$$(\bar{G}-G_t)=\frac{\alpha^2\delta_1(\bar{g}+v_i)}{\left(1+\frac{g_2}{g_1}\right)[\delta_2(1+\alpha^2\mu_1)+\alpha^2\mu_2\delta_1]}+\frac{\alpha^2\delta_1(\bar{g}+v_i)}{\left(1+\frac{g_1}{g_2}\right)[\delta_2(1+\alpha^2\mu_1)+\alpha^2\mu_2\delta_1]}$$

$$(\bar{G}-G_t)=\frac{\left(1+\frac{g_1}{g_2}\right)\alpha^2\delta_1(\bar{g}+v_i)}{\left(1+\frac{g_2}{g_1}\right)\left(1+\frac{g_1}{g_2}\right)[\delta_2(1+\alpha^2\mu_1)+\alpha^2\mu_2\delta_1]}+\frac{\left(1+\frac{g_2}{g_1}\right)\alpha^2\delta_1(\bar{g}+v_i)}{\left(1+\frac{g_2}{g_1}\right)\left(1+\frac{g_1}{g_2}\right)[\delta_2(1+\alpha^2\mu_1)+\alpha^2\mu_2\delta_1]}$$

$$(\bar{G}-G_t)=\frac{\left(1+\frac{g_1}{g_2}\right)\alpha^2\delta_1(\bar{g}+v_i)+\left(1+\frac{g_2}{g_1}\right)\alpha^2\delta_1(\bar{g}+v_i)}{\left(1+\frac{g_2}{g_1}\right)\left(1+\frac{g_1}{g_2}\right)[\delta_2(1+\alpha^2\mu_1)+\alpha^2\mu_2\delta_1]}$$

$$(\bar{G} - G_t) = \frac{\left(2 + \frac{g_1}{g_2} + \frac{g_2}{g_1}\right)\alpha^2\delta_1(\bar{g} + v_i)}{\left(1 + \frac{g_2}{g_1} + \frac{g_1}{g_2} + \frac{g_2 g_1}{g_1 g_2}\right)[\delta_2(1 + \alpha^2\mu_1) + \alpha^2\mu_2\delta_1]}$$

$$(\bar{G} - G_t) = \frac{\left(2 + \frac{g_1}{g_2} + \frac{g_2}{g_1}\right)\alpha^2\delta_1(\bar{g} + v_i)}{\left(2 + \frac{g_2}{g_1} + \frac{g_1}{g_2}\right)[\delta_2(1 + \alpha^2\mu_1) + \alpha^2\mu_2\delta_1]}$$

$$(\bar{G} - G_t) = \frac{\alpha^2\delta_1(\bar{g} + v_i)}{[\delta_2(1 + \alpha^2\mu_1) + \alpha^2\mu_2\delta_1]}$$

These outcomes are denoted as equation 16 in the analysis.

Appendix 3: Derivation of the policy outcomes of a commitment regime with two fiscal authorities

To get to the derivation, the first order conditions of the central bank and the fiscal authorities are used. However, these first-order conditions are altered to the conditions under the commitment regime where the monetary authority knows that he will determine inflation in advance.

CB: $\pi + \mu_2([g_1 + g_2] - \bar{G}) = 0$

FA: $-\alpha\delta_1 x_i + \delta_2(g_i - \bar{g}) = 0$

Since the fiscal authority determines the output level, the derivation of the output level is based upon the first order condition of the fiscal authority. This comes to equation 17a:

$$-\alpha\delta_1 x_i + \delta_2(g_i - \bar{g}) = 0$$

$$\alpha\delta_1 x_i + \delta_2(\bar{g} - g_i) = 0$$

$$\alpha\delta_1 x_i = -\delta_2(\bar{g} - g_i)$$

$$x_i = -(\delta_2/\alpha\delta_1)(\bar{g} - g_i)$$

X is built on the two separate output levels which comes to equation 17b:

$$X = -(\delta_2/\alpha\delta_1)(\bar{g} - g_1) + -(\delta_2/\alpha\delta_1)(\bar{g} - g_2)$$

$$X = \frac{-\delta_2(\bar{g} - g_1) + -\delta_2(\bar{g} - g_2)}{\alpha\delta_1}$$

$$X = \frac{-\delta_2(\bar{g} - g_1 + \bar{g} - g_2)}{\alpha\delta_1}$$

$$X = -(\delta_2/\alpha\delta_1)(\bar{G} - G_t)$$

The level of inflation is still, in any case ultimately, determined by the central bank. This is equation 17c:

$$\pi + \mu_2([g_1 + g_2] - \bar{G}) = 0$$

$$\pi = \mu_2(\bar{G} - [g_1 + g_2])$$

$$\pi = \mu_2(\bar{G} - G)$$

The government spending equation and output equation are modified and combined in the same way as in the discretionary regime, getting to:

$$x_t = \alpha(-\bar{g} + \pi_t - v_i)$$

To balance the budget, the equation above will have to be equal to the outcome of the output in equilibrium.

$$-(\delta_2/\alpha\delta_1)(\bar{g} - g_i) = \alpha(-\bar{g} + \pi_t - v_i)$$

Furthermore, the inflation rate has already been determined above. This outcome will be entered into this equation as well. This leads to equation 17d:

$$-(\delta_2/\alpha\delta_1)(\bar{g} - g_i) = \alpha(-\bar{g} - v_i + [\mu_2(\bar{G} - G)])$$

$$\frac{(\delta_2/\alpha\delta_1)(\bar{g} - g_i)}{\alpha} = \bar{g} + v_i - [\mu_2(\bar{G} - G)]$$

$$\frac{(\delta_2/\alpha\delta_1)}{\alpha} = \frac{\bar{g} + v_i}{(\bar{g} - g_1)} - \left[\mu_2\left(\frac{g_2}{g_1} + 1\right)\right]$$

$$\frac{\bar{g} + v_i}{(\bar{g} - g_1)} = \frac{(\delta_2/\alpha\delta_1)}{\alpha} + \left[\mu_2\left(\frac{g_2}{g_1} + 1\right)\right]$$

$$\frac{\bar{g} + v_i}{(\bar{g} - g_1)} = \frac{\delta_2}{\alpha^2\delta_1} + \left[\mu_2\left(\frac{g_2}{g_1} + 1\right)\right]$$

$$\frac{\bar{g} + v_i}{(\bar{g} - g_1)} = \frac{\delta_2}{\alpha^2\delta_1} + \left[\frac{\alpha^2\delta_1\mu_2\left(\frac{g_2}{g_1} + 1\right)}{\alpha^2\delta_1}\right]$$

$$\frac{\bar{g} + v_i}{(\bar{g} - g_1)} = \frac{\delta_2 + \left[\alpha^2\delta_1\mu_2\left(\frac{g_2}{g_1} + 1\right)\right]}{\alpha^2\delta_1}$$

$$\frac{\alpha^2\delta_1(\bar{g} + v_i)}{(\bar{g} - g_1)} = \delta_2 + \alpha^2\delta_1\mu_2\left(\frac{g_2}{g_1} + 1\right)$$

$$(\bar{g} - g_1) = \frac{\alpha^2\delta_1(\bar{g} + v_i)}{\alpha^2\delta_1\mu_2\left(\frac{g_2}{g_1} + 1\right)}$$

$$(\bar{g} - g_1) = \frac{(\bar{g} + v_i)}{\mu_2\left(\frac{g_2}{g_1} + 1\right)}$$

When going back to $\bar{G} - G_t$, the outcomes for the two countries are taken together gets to 17e:

$$(\bar{G} - G_t) = \frac{(\bar{g} + v_i)}{\mu_2\left(\frac{g_2}{g_1} + 1\right)} + \frac{(\bar{g} + v_i)}{\mu_2\left(\frac{g_1}{g_2} + 1\right)}$$

$$(\bar{G} - G_t) = \frac{\left(\frac{g_1}{g_2} + 1\right)(\bar{g} + v_i)}{\mu_2\left(\frac{g_2}{g_1} + 1\right)\left(\frac{g_1}{g_2} + 1\right)} + \frac{\left(\frac{g_2}{g_1} + 1\right)(\bar{g} + v_i)}{\mu_2\left(\frac{g_2}{g_1} + 1\right)\left(\frac{g_1}{g_2} + 1\right)}$$

$$(\bar{G} - G_t) = \frac{\left(\frac{g_2}{g_1} + 1\right)\left(\frac{g_1}{g_2} + 1\right)(\bar{g} + v_i)}{\mu_2\left(\frac{g_2}{g_1} + 1\right)\left(\frac{g_1}{g_2} + 1\right)}$$

$$(\bar{G} - G_t) = \frac{\left(1 + \frac{g_1}{g_2}\right)\alpha^2\delta_1(\bar{g} + v_i) + \left(1 + \frac{g_2}{g_1}\right)\alpha^2\delta_1(\bar{g} + v_i)}{\left(1 + \frac{g_2}{g_1}\right)\left(1 + \frac{g_1}{g_2}\right)[\delta_2(1 + \alpha^2\mu_1) + \alpha^2\mu_2\delta_1]}$$

$$(\bar{G} - G_t) = \frac{\left(2 + \frac{g_1}{g_2} + \frac{g_2}{g_1}\right)(\bar{g} + v_i)}{\left(1 + \frac{g_2}{g_1} + \frac{g_1}{g_2} + \frac{g_2 g_1}{g_1 g_2}\right)\mu_2}$$

$$(\bar{G} - G_t) = \frac{\left(2 + \frac{g_1}{g_2} + \frac{g_2}{g_1}\right)(\bar{g} + v_i)}{\left(2 + \frac{g_2}{g_1} + \frac{g_1}{g_2}\right)\mu_2}$$

$$(\bar{G} - G_t) = \frac{(\bar{g} + v_i)}{\mu_2}$$

These outcomes are denoted as equation 17 in the analysis