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## Deciding about (de-)centralization of industrial policy: Delegation by a central authority vs. bargaining of regional governments

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**Universität der Bundeswehr München**  
Institut für Volkswirtschaftslehre



Karl Morasch

**Deciding about (De-)centralization  
of Industrial Policy:  
Delegation by a Central Authority vs.  
Bargaining of Regional Governments**

**Disziplin**

# Deciding about (De-)centralization of Industrial Policy

## Delegation by a Central Authority vs. Bargaining of Regional Governments

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Universität der Bundeswehr München  
Diskussionsbeiträge des Instituts für Volkswirtschaftslehre  
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## Abstract

In the European Union the commission has the primary right to decide about industrial policy. Note that this includes the possibility to allow actions of member countries as long as these are not in conflict with the interest of the EU. This paper deals with the question whether such an assignment of decision rights is appropriate by comparing it with a more decentral system where the decision power is in the hands of the member countries which, however, may agree to delegate this power on a case by case basis to a central authority. The analysis is performed in an integrated Cournot duopoly with domestic and third country consumption. Here it depends on the export ratio and the degree of uncertainty whether industrial policy is better performed by a central authority that internalizes spillovers or by regional governments with superior information about the costs of the regional firm. To analyze how the initial allocation of decision rights affects the actual assignment of power for a specific industry we compare two situations: (i) An uninformed central authority decides about delegation to regional governments. (ii) Asymmetrically informed regional governments bargain about empowering a central authority. Interestingly delegation outperforms bargaining on average in a setting with side payments but without information transfer. If, however, signals obtained in the bargaining stage are used to update the own information, bargaining without side payments delivers in expectation a better result than delegation.

Key words: Delegation; Bargaining; Industrial policy; (De-)centralization

Die europäische Kommission ist primärer Träger der Industriepolitik in der europäischen Union. Industriepolitische Aktivitäten der Mitgliedsländer können jedoch zugelassen werden, solange sie nicht den Interessen der Union zuwiderlaufen. Das vorliegende Papier beschäftigt sich mit der Frage, ob diese Zuordnung der Entscheidungsmacht sinnvoll ist. Dazu wird als Vergleichsbasis ein dezentrales System mit Befugnissen auf Seiten der einzelnen Länder, aber mit Möglichkeit zur fallweisen Delegation auf eine zentrale Instanz herangezogen. Analysiert wird das Problem im Rahmen eines Cournot Duopols auf einem integrierten Weltmarkt mit heimischem und Drittland-Konsum. Dabei hängt es von der Exportquote und dem Grad der Unsicherheit ab, ob Industriepolitik besser von einem zentralen Träger durchgeführt wird, der Spillovers internalisiert, oder von den regionalen Regierungen, die über bessere Informationen bezüglich der Kosten des jeweiligen regionalen Unternehmens verfügen. Um die Auswirkung der ursprünglichen Verteilung der Entscheidungsmacht auf die tatsächliche Zuordnung der Kompetenz in einer bestimmten Branche zu analysieren werden zwei Situationen verglichen: (i) Ein uninformatierter zentraler Träger entscheidet über die Delegation an die regionalen Regierungen. (ii) Asymmetrisch informierte regionale Regierungen verhandeln darüber, ob die Industriepolitik regional oder durch eine zentrale Instanz durchgeführt werden soll. Interessanterweise schneidet bei Verhandlungen mit Seitenzahlungen die Delegationslösung trotz der Informationsvorteile der regionalen Regierungen im Durchschnitt besser ab, solange im Rahmen der Verhandlung kein Informationstransfer erfolgt. Werden jedoch die im Rahmen der Verhandlung empfangenen Signale zur Anpassung der eigenen Wahrscheinlichkeitsschätzungen herangezogen, so ist die Verhandlungslösung ohne Seitenzahlungen zumindest im Erwartungswert effizienter.

Schlagworte: Delegation; Verhandlungen; Industriepolitik; (De-)Zentralisierung, Produktdifferenzierung

JEL-classification: D43, H70, L52

# 1 Introduction

Industrial policy has basically two goals: (i) Imperfect markets do not yield an efficient allocation. Thus the government has an incentive to correct for these market failures. This objective will only incidentally lead to a conflict between governments in different countries or regions. (ii) As discussed by the theory of strategic trade policy, in imperfect markets governments may have an incentive to shift rents from foreign firms to domestic firms. This aspect clearly leads to externalities between different states. A prisoners dilemma results: All countries would be better off if regional governments refrain from a rent shifting policy but there is a unilateral incentive to deviate from the non-policy option.

In a situation with perfect information it would therefore be preferable to give the decision power to a central authority that will implement an industrial policy that is only concerned with the first goal. But in reality local governments may have superior information about local aspects which are not perfectly communicable to a central government.<sup>1</sup> Depending on the relative importance of information advantages and the externality problems mentioned above either central or decentral policy may be preferable. This kind of trade-off has been explicitly analyzed in a local public good context by LAFFONT/ZANTMAN (2002) and a similar kind of reasoning can be found in GILBERT/PICARD (1996) who analyze the optimal size of local jurisdictions. In these papers, however, the intensity of the externality is modeled as an exogenous parameter. We endogenize this variable by discussing the problem in the context of an integrated Cournot duopoly where the central government has imperfect information about firms' cost. As shown in MORASCH (1997 and 2003, ch. 3.1), in this setting it depends on the amount of third country consumption and the degree of cost uncertainty whether it is optimal to assign the power to a central authority or to regional governments.<sup>2</sup>

In an ideal world, the information about consumption patterns and cost uncertainty in a specific industry would be determined by an economic analysis and, based on these results, the power over industrial policy would be optimally assigned. In real world politics, however, choices are not necessarily made according to economists' advice but crucially depend on the decision process and the bargaining power of the parties involved. This aspect will be analyzed in the present paper by comparing the following two settings:

- Initially the right to perform industrial policy is assigned to regional governments. This is for example the case if sovereign nations bargain about the delegation of powers to the World Trade Organization (WTO). The delegation to such a central authority will only result if all countries agree.

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<sup>1</sup>A general discussion how limits to communication may explain decentralization can be found in POITEVIN (2000).

<sup>2</sup>For an alternative explanation of the relative performance of centralization and decentralization in the context of industrial policy see CAILLAUD ET. AL. (1996). An argument that favors centralization of industrial policy in an oligopoly context is put forth in COLLIE (2000).

- The central government has the decision power over industrial policy but may delegate this power to the regional authorities. This resembles the situation within most countries where regional authorities like the Bundeslaender in Germany or the States in the United States have only limited power. It should also be a realistic description of the situation in the European Union where the Commission is primarily responsible for industrial policy.

Under perfect information the efficient decision about delegation would not be affected by the initial assignment of power: The Coase theorem asserts that the parties will achieve an efficient outcome irrespective of the distribution of bargaining power. This, however, is no longer assured under the more realistic assumption of asymmetric information. We will deal with this setting by analyzing the relative performance of delegation under uncertainty versus bargaining under asymmetric information.

The remainder of the paper is organized as follows: In section 2 the basic structure of the model, especially with respect to timing and information, will be presented. Section 3 describes the industrial policy stage of the game for centralization and decentralization. Based on this information, bargaining among regional governments is analyzed in section 4 and the outcomes of bargaining and delegation are compared for different assumptions about the bargaining game. Section 5 concludes by discussing the driving forces behind the results obtained.

## 2 Timing and Information Structure

The problem of deciding about centralization vs. decentralization of industrial policy is analyzed by comparing two three stage games. These games only differ with respect to the first stage: In the “delegation game” the central authority decides about giving the decision power to the regional governments while these governments bargain about delegation to a central authority in the “bargaining game”. In the second stage, depending on the decision in the first stage, either central authority or regional governments impose an industrial policy via production subsidies or taxes. In the third stage firms compete in an integrated duopoly market.

The game structure in stages two and three is based on the strategic trade policy model from BRANDER/SPENCER (1985): The domestic country consists of two regions with one Cournot firm in each region. These firms produce a homogenous good for an integrated market comprising the two regions of the domestic market and a third country which is solely a importer of the good (if the firms would only produce for the third country market this would be perfectly equivalent to the standard formulation in BRANDER/SPENCER, 1985). Industrial policy is modeled as an output subsidy (or tax if applicable): Either the central government determines an identical per unit subsidy or tax  $s$  for all firms or each regional government chooses a subsidy  $s_i$  for the regional firm. In both cases the actual subsidy to a firm is financed in lump sum fashion in the region where the firm is active (in the case of a tax the revenue is distributed accordingly). This assures that central industrial policy only affects incentives but does not lead to pecuniary transfers between regions.

For a Cournot model with general demand and cost conditions the following result has been obtained in MORASCH (1997): If the product is only exported to the third country, central industrial policy will be preferred irrespective of information problems as long as both firms have identical costs. However, if the product is not exported to the third country, decentral policy leads to the same result as central policy for symmetric information and thus dominates central policy in the case of asymmetric information. The general formulation does not allow to determine which policy option is superior if part of the production is exported to the third country or if firms could have different costs. Because explicit results at the policy stage are necessary to determine the incentives in the first stage of each game, we consider a linear specification of the duopoly game that will be described in detail in section 3.

Before explicitly dealing with the delegation and the bargaining stage, respectively, we must consider how the information structure changes during the game:

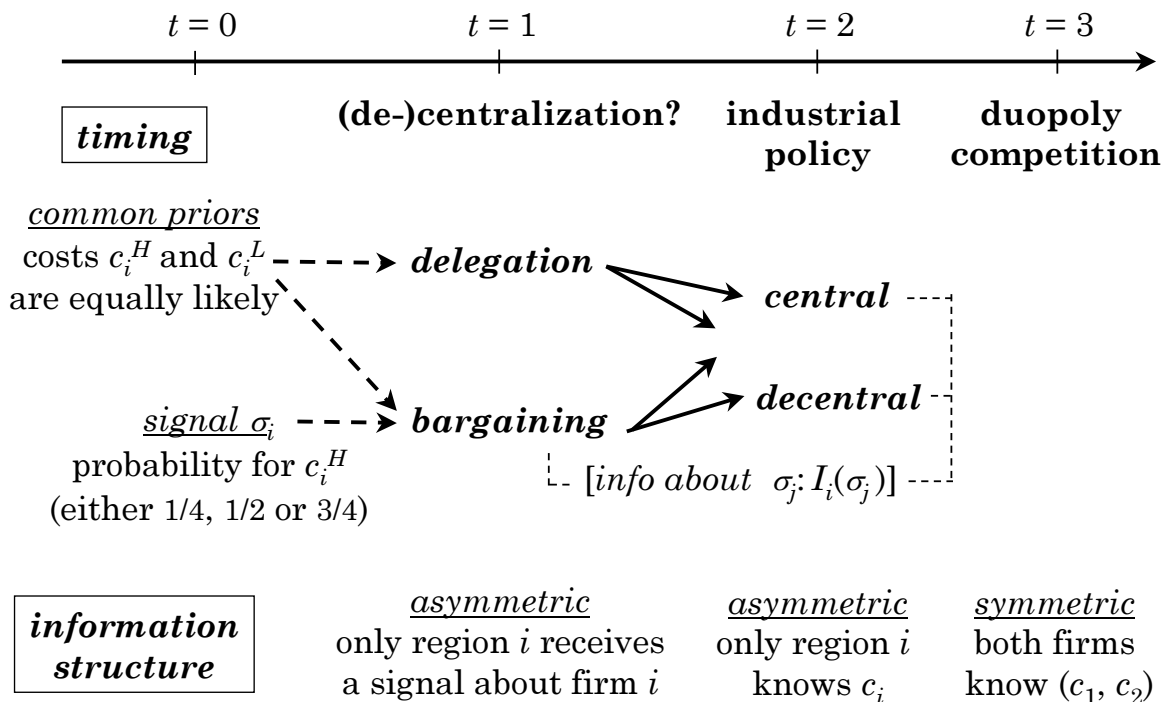
- I assume that all players are aware of the structure of the game and initially central and regional governments have the same (imperfect) information about firms' costs (common priors): For each firm  $i$  high costs,  $c_i^H$ , and low costs,  $c_i^L$ , are equally likely.
- Before bargaining starts, each regional government obtains some additional information about the prospective costs of its firm. Formally it is assumed that the policy maker in region  $i$  observes a signal  $\sigma_i \in \{l, m, h\}$  with  $l$  indicating a low probability  $P_i^l = 1/4$  for high costs,  $m$  a medium probability  $P_i^m = 1/2$ , and  $h$  a high probability  $P_i^h = 3/4$ ; all three possible realizations of  $\sigma_i$  are equally likely. This leads to asymmetric information in the bargaining stage and an informational disadvantage for the central government. Note that the signal does not lead to perfect information but just to a more accurate estimate of the actual costs: The idea is that a regional government will only acquire further information about its firm if it actually has to perform the industrial policy.
- As a result of the bargaining game the private information may be, at least partially, revealed to the other parties. I distinguish two scenarios: (i) Information obtained at the bargaining stage does not influence the behavior in the policy stage. Thus signaling aspects are neglected. This assumption greatly simplifies the analysis and makes it possible to analyze some interesting aspects of bargaining under asymmetric information in isolation. (ii) More realistically the information, which reflects a more accurate estimate of the actual costs of the regional firms, may be used by the government of the other region or a central authority when deciding about the optimal subsidy level. Formally the common priors are updated by region  $i$  or the central government, respectively, by considering the information  $I_i(\sigma_j)$  disclosed by the behavior of region  $j$  in the bargaining stage. Note that regional governments obtain perfect information about the costs of their firms before they determine industrial policy in stage two of the game. So even if the private information at stage one is completely revealed, there is still asymmetric information in the policy stage.



- In the duopoly game at the third stage firms are assumed to know each others costs. The reason for this assumption is to abstract from signaling aspects at the policy stage which have been already discussed in the strategic trade policy literature (see COLLIE/HVIID, 1993, QIU, 1994 and BRAINARD/MARTIMORT, 1996).

In stage one of the game it is assumed that a central authority will delegate the power to perform the industrial policy if the expected ex ante welfare is maximized by this decision. Alternatively independent regional governments may bargain over cooperation, i. e. to delegate the decision to a central institution which tries to maximize joint welfare. The bargaining strategies are chosen to maximize expected regional welfare where expectations are built based on the signals received prior to the bargaining stage. I distinguish situations with and without side payments. Allowing side payments may be more realistic but especially the case with information linkages becomes quite messy under this assumption. Also it is helpful to abstract from side payments in a first step to get a better understanding of the incentives of regional governments. Figure 1 illustrates the timing and the information structure of the two games.

Figure 1: Timing and Information Structure



### 3 Central vs. Decentral Industrial Policy

The incentives in the delegation and bargaining game at stage one depend on the effect of decentral or central policy on regional and total (domestic) welfare. In this section a relatively simple linear duopoly model will be analyzed to obtain explicit welfare results. The model is constructed in a way that allows a parametrization of the share of domestic consumption and the “degree” of uncertainty, the two parameters which together determine the relative performance of central and decentral policy.

In a first step the game in the output stage shall be described. Two firms with constant average costs  $c_i$  are assumed to compete in Cournot fashion in an integrated homogenous good market with linear demand  $p(X) = 1 - X$ . The costs which may either be high,  $c^H$ , or low,  $c^L$ , are known to both firms. For given output based subsidies  $(s_1, s_2)$  the equilibrium quantities in the output game are easily determined by simultaneously solving the firms’ first order conditions for profit maximization:

$$x_i^*(s_1, s_2) = 1/3(1 - 2c_i + c_j + 2s_i - s_j). \quad (1)$$

In the policy stage the governments try to maximize welfare by manipulating the output structure via appropriate subsidies or taxes. The output of the regional firm affects the regional welfare through two channels: The profits of the firm and the effect on consumer surplus. For simplicity it will be assumed that the two producing have identical consumption patterns. Thus the share of total production which is consumed in a given region may be described by  $\gamma = \gamma_1 = \gamma_2 \in [0, 0.5]$  — if  $\gamma = 0$  all output is exported to the third country while  $\gamma = 0.5$  indicates that everything is consumed within the producing countries (because markets are integrated, it is irrelevant whether the goods consumed in region  $i$  are produced in this region or in region  $j$ ).

The welfare  $W_i$  of region  $i$  may be derived by summing up the profits of the regional firm and the consumer surplus in this region:

$$W_i(x_1, x_2) = [1 - c_i - (x_1 + x_2)]x_i + \gamma \frac{(x_1 + x_2)^2}{2} \quad (2)$$

The regional government  $i$  tries to maximize  $W_i$  while the central government is concerned with  $W = W_1 + W_2$ . Inserting the equilibrium quantities in the output stage from equation 1, welfare may be written as a function of subsidies and costs.

Contrary to the output game, asymmetric information about costs is assumed in the policy stage. Each regional government only knows the costs of its “own” firm but not the costs of the firm in the other region. The central authority and the government in region  $i$  both assign probability  $P_j$  that the costs of the firm in region  $j$  are  $c^H$  and probability  $(1 - P_j)$  that they are  $c^L$ . While perfect information about costs by the regional government and both firms is surely a simplifying assumption, the structure of the information asymmetry should be realistic: Firms interact with each other and the regional government may have close contact to the regional

firm. Thus they will have better information about costs than the central government or the government of the other region.

How can the equilibrium for the policy game with decentral policy be determined? Because the regional governments do not have perfect information about the costs of the other firm, the standard Nash equilibrium is not a suitable solution concept for the policy game. When deciding about the optimal subsidy each regional government has to build expectations about the “type” of firm which is active in the other region. As a solution concept the Bayes–Nash–equilibrium applies: Here a game between the different types of regional governments — regions with low cost firms and regions with high cost firms — is considered. Let  $t_i \in L, H$  indicate the type of the region  $i$ , i. e. whether the firm producing in this region has low or high costs. The regional government  $i$  which is of type  $t_i$  tries to figure out the welfare maximizing subsidy  $s_i^{t_i}$  to its firm given its expectation about the type  $t_j$  of the other region.

With  $W_i^{t_i t_j}(s_i^{t_i}, s_j^{t_j})$  as welfare in region  $i$  if the regions are of type  $t_i$  and  $t_j$  and choose the corresponding subsidies, the reaction function of a regional government of type  $t_i$  will be obtained by differentiating  $P_j W_i^{t_i H}(s_i^{t_i}, s_j^H) + (1 - P_j) W_i^{t_i L}(s_i^{t_i}, s_j^L)$  with respect to  $s_i^{t_i}$ . This leads to four reaction functions of the following form:<sup>3</sup>

$$s_i^{t_i}(s_j^L, s_j^H) = \frac{(1 + 2\gamma) - (2 + \gamma)c_i^{t_i} + (1 - \gamma)[P_j(c_j^H - s_j^H) + (1 - P_j)(c_j^L - s_j^L)]}{(4 - \gamma)} \quad (3)$$

Based on this system of four equations the type dependent subsidy levels can be derived.

$$s_i^{t_i*} = \frac{(4 - \gamma)(2\gamma + 1) - (2 + \gamma)(5 - 2\gamma)c_i^{t_i}}{(4 - \gamma)(5 - 2\gamma)} + \frac{2(1 - \gamma)[-(1 - \gamma)(P_i c_i^H + (1 - P_i)c_i^L] + (4 - \gamma)(P_j c_j^H + (1 - P_j)c_j^L)]}{(4 - \gamma)(5 - 2\gamma)} \quad (4)$$

The subsidy level decreases with higher actual costs  $c_i^{t_i}$  and also with higher expected costs  $P_i c_i^H + (1 - P_i)c_i^L$ . The second effect is due to the strategic interaction between the governments: If the expected costs in region  $i$  increase, the government of the other region will increase its subsidy and thus the government of region  $i$  will use a lower subsidy in equilibrium.

The optimal subsidy level in the case of central policy is determined by maximizing the following function for expected welfare:

$$EW(s) = P_1 P_2 W^{HH}(s) + P_1(1 - P_2)W^{HL}(s) + (1 - P_1)P_2 W^{LH}(s) + (1 - P_1)(1 - P_2)W^{LL}(s) \quad (5)$$

This leads to a subsidy level

$$s^* = \frac{(4\gamma - 1)[2 - (P_1 c_1^H + P_2 c_2^H + (1 - P_1)c_1^L + (1 - P_2)c_2^L)]}{8(1 - \gamma)}. \quad (6)$$

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<sup>3</sup>Note that for substantial cost differences a high cost firm will be forced to leave the market if it faces a low cost competitor. However, the reaction functions are only correct as long as both firms produce in equilibrium. In the following analysis parameter values are restricted accordingly to assure positive quantities in all circumstances.

The central government taxes the firms if at least 50% of the production is exported. Otherwise positive subsidies will be used.

Under perfect information (both  $P_i$  either 0 or 1) the subsidy  $s^*$  would be lower than the subsidies in the equilibrium between the regional governments for  $\gamma < 0.5$ . Central industrial policy would then lead to higher welfare because the regional governments do not consider the negative impact of the subsidies to their regional firm on the profits of the firm in the other region. This is no longer assured under asymmetric information: For  $\gamma$  close to 0.5 the subsidies for regional policy may be more in accordance with the optimal (perfect information) subsidy structure because they better reflect the actual cost structure. No general statement is possible: The relative performance of the two policies depends on the exact values of  $P_i$ ,  $c_i$  and  $\gamma$ .

To make the economic interpretation easier, a one dimensional measure for the “degree” of cost uncertainty will be introduced. The importance of asymmetric information depends on the difference between  $c^H$  and  $c^L$  and on the probabilities for high costs,  $P_i$ . It will be assumed that initially both values of  $c$  are equally likely, i. e. the common prior probability for high costs  $c^H$  is given by  $P_i^0 = 1/2$ . Given this the following symmetric specification seems to be appropriate: The two possible realizations may be expressed as  $c^L = E(c) - d$  and  $c^H = E(c) + d$  with  $E(c)$  being the expected value of  $c$  and  $d$  representing a measure for the “degree” of uncertainty. In the linear model with demand  $p(X) = 1 - X$  the costs could take values between zero and one; therefore I assume  $E(c) = 1/2$  and thus  $d$  can take values in the interval  $[0, 0.5[$ . A low value of  $d$  indicates that the central government knows the actual costs almost exactly while higher values represent higher degrees of uncertainty.

Now it is possible to analyze how the share of domestic consumption  $\gamma$  and the degree of uncertainty  $d$  affect the relative performance of central policy  $CP$  and decentral policy  $DP$ . With  $EW(CP)$  defined as  $EW(s^*)$  and  $EW(DP)$  as

$$EW(DP) = P_1 P_2 W^{HH}(s_1^{H*}, s_2^{H*}) + P_1(1 - P_2)W^{HL}(s_1^{H*}, s_2^{L*}) + (1 - P_1)P_2 W^{LH}(s_1^{L*}, s_2^{H*}) + (1 - P_1)(1 - P_2)W^{LL}(s_1^{L*}, s_2^{L*}) \quad (7)$$

the ex ante welfare difference (i. e. expected welfare based on the common prior probabilities  $P_i^0$ ) between the two policy options can be written as

$$EW(CP) - EW(DP) = \frac{9(2\gamma - 1)^2}{16(1 - \gamma)(5 - 2\gamma)^2} - 2d^2 \frac{(7 - \gamma)(2 + \gamma)^2}{9(4 - \gamma)^2}. \quad (8)$$

The first term in expression (8) is positive and the second is negative and increasing in  $d$ : A higher degree of uncertainty makes regional policy relatively more attractive. Differentiating with respect to  $\gamma$  leads to an expression which is always negative in the relevant range for  $\gamma$  and  $d$ : For a given  $d$  the regional solution performs better if the share of domestic consumption is relatively high.

If the firms have different costs it is possible that the inefficient firm will not have an incentive to produce in equilibrium. Because considering border solutions would greatly complicate

the analysis, I will restrict attention to the parameter range where both firms produce in equilibrium. Straightforward calculations show that the necessary  $x_i^*(c_i^H, c_j^L) > 0$  will be fulfilled for all values of  $\gamma$  if  $d < 1/8$  (for details see MORASCH, 1997 or 2003, ch. 3.1) Note that  $d = 1/8$  would denote a cost difference of more than 50 %. Thus even for substantial cost differences both firms will produce in equilibrium.

## 4 Comparing Delegation and Bargaining

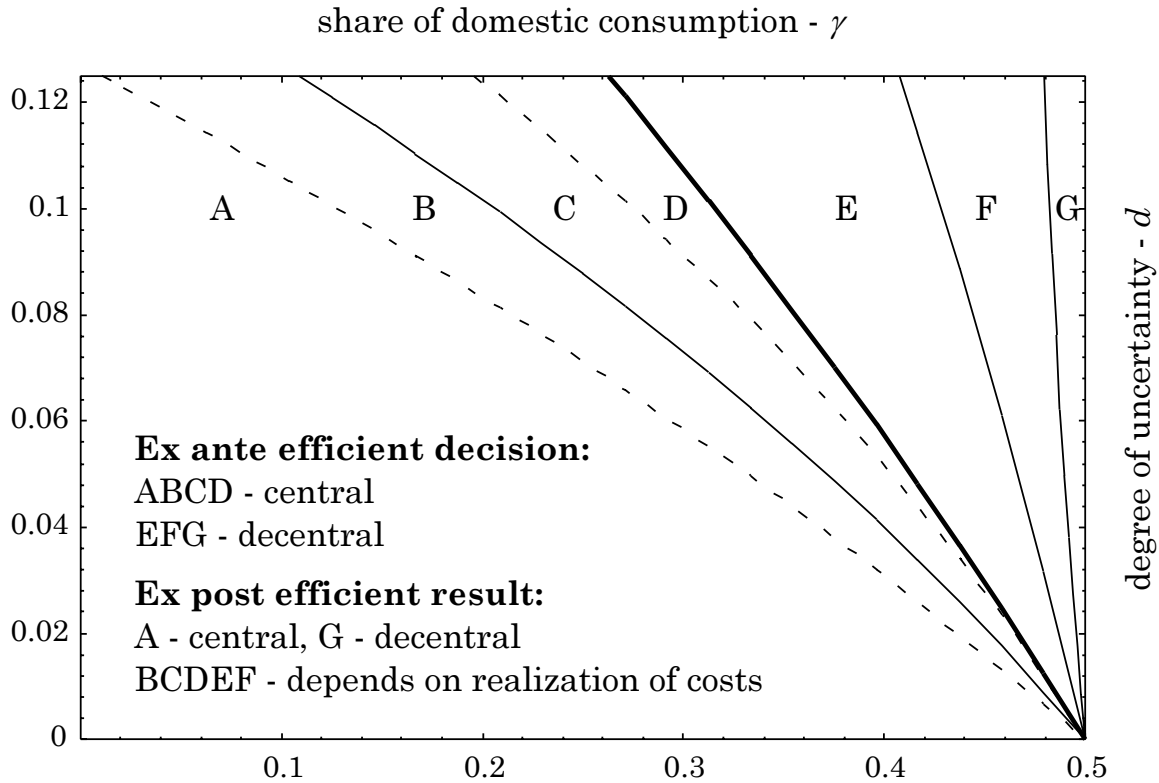
Now the results of delegation by a central authority will be compared with the outcome of bargaining by regional governments. The analysis in the preceding section showed whether centralization or decentralization is optimal from an ex ante perspective, i. e. at the point of time when no private information has yet been revealed. If the decision is made in this state, delegation and cooperation would lead to the same (ex ante efficient) result because without asymmetric information the Coase theorem applies: Efficiency is assured independent of the division of bargaining power. However, this is not the case in our analysis because we assume that each regional policy maker receives a signal about the prospective costs of its firm before bargaining takes place. How does this signal affect the incentives in the bargaining stage? Two effects may be distinguished: (i) The signal changes the probability that a region assigns to the different realizations of the cost structure. (ii) If the signal is (partially) revealed to the other region during the bargaining process, the behavior in the policy stage and thus the outcome for a given cost structure will be changed. We start by considering the first aspect in isolation — the more complex signalling game will be discussed at the end of the section.

### 4.1 Bargaining incentives and welfare criteria

It is difficult to rationalize the assumption that common priors about costs are not updated based on the observable behavior of the regional government in the bargaining stage (an attempt is made in MORASCH, 2003, 169). However, abstracting from signalling aspects greatly simplifies the analysis and helps us to deal with some specific aspects of bargaining with side payments.

In order to get an understanding how the signal  $\sigma_i$  changes the bargaining incentives it is helpful to take a look at the ex post preferability of the two policy options: Which policy is optimal for a realized cost structure  $(c_1, c_2)$ ? Note that the behavior in the policy stage is not affected by the signals as long as this information is not revealed to the other region or the central authority: At the policy stage the regional governments know the actual costs of their firms and so the initial probabilities for these costs become irrelevant for their behavior. Whether central or decentral policy yields higher welfare may than easily be determined by comparing ex post welfare under decentralization,  $W_i^{t_i t_j}(s_i^{t_i*}, s_j^{t_j*})$ , with the respective welfare under centralization,  $W_i^{t_i t_j}(s^*)$ . Figure 2 shows the respective parameter range in  $(\gamma, d)$ -space

Figure 2: Ex ante criterion and ex post optimal policy



Source: Mathematica plot based on own calculations

for each cost structure and in addition the borderline for the ex ante decision criterion, i. e. the optimal assignment based on common priors.

The central authority must follow the ex ante criterion when deciding about delegation: In areas ABCD the expected welfare is higher under central policy, while delegation to regional policy makers is preferable for parameter combinations in EFG. Note that for a substantial degree of uncertainty, decentral policy is chosen for realistic export shares (e. g.  $\gamma = 0.4$  indicates an export share to the third country of 20%). However, if export shares exceed 50% central policy will always be preferred.

Now let us consider the ex post optimal policy. There are two areas where the delegation decision of the central government is assured to be correct: In A the central solution is preferred ex ante (A is left of the thick solid line) and will be optimal ex post for all possible cost structures — for a relatively low degree of uncertainty and a relatively high export level the externality problem dominates the information advantages of the regional solution. In area G the decentral solution is optimal ex ante and ex post: The good is consumed almost completely within the two producing regions (the externality problem of regional policy is unimportant) and the degree of uncertainty is substantial. However, in the parameter range between these extremes a decision

based on ex ante welfare might be suboptimal ex post: If costs of both firms are actually identical, decentral policy which is preferable ex ante may be worse than central policy from an ex post perspective (in EF). On the other hand, if costs differ, the central policy option might be wrongly chosen (in BCD). The latter result stems from the fact that identical subsidies are imposed under central policy while the decentral solution yields a subsidy structure with a higher subsidy to the low cost firm which enhances efficiency because a larger share of total output is now produced by this firm.

Note that this effect is only part of the whole story: Incentives also differ between regions with high cost and low cost firms. At first glance one would expect that the region with a low cost firm would prefer the decentral solution because higher subsidies would rise firm profits. However, this is not the case:

- For identical costs high cost regions prefer decentralization in both F and G while low cost regions would favour centralization in area F. How can this be explained? Under perfect information equilibrium subsidies under decentralization would be higher than the optimal subsidy imposed by a central government. With imperfect information the central authority must compromise between an optimal subsidy for high cost and low cost firms. For  $\gamma$  close to 0.5 it is in both cases possible that the equilibrium subsidy under decentralization is closer to the first best than the centrally determined subsidy. However, only in the high cost case the subsidy under centralization exceeds the optimal perfect information subsidy. This acts as a counterbalance to the effect that decentral subsidies are too high and thus in the high cost case decentral policy is preferred for a larger parameter range.
- For different costs the high cost region is also more likely to favor decentralization: While total welfare is maximized by centralization in area AB, regional welfare of the low cost and the high cost region are higher in ABC and A, respectively. The reason is as follows: The higher subsidy to the low cost firm under decentralization leads to lower net profits (i. e. without subsidy payments) for this firm. The profits of the high cost firm are also reduced but these profits are relatively unimportant for regional welfare. On the other hand the higher average subsidies under decentralization yield more output and thus increased consumer surplus. The decentral solution is preferred for a larger parameter range in the case of the region with a high cost firm because the profit effect is relatively unimportant while the higher consumer surplus induced by higher total production is equally favorable for both regions.

Based on these considerations we are now able to discuss how incentives of regional authorities are affected by the probabilities  $(P_i, P_j)$  they assign for high costs of the own firm and its competitor, respectively.

- If it is more likely that the firms have different costs, i. e. if  $P_i(1 - P_j)$  is higher, decentralization is preferable for a larger parameter range.

- A higher probability of high costs makes the decentral solution relatively more attractive. A region is thus most likely to prefer central policy for  $(P_i^l, P_j^l)$  because the probability of low costs and of identical costs are both high. On the other hand region  $i$  prefers the decentral solution for the largest parameter range in the case of  $(P_i^h, P_i^l)$  — here high costs of the own firm and different costs of the two firms are both quite likely. Note, however, that without information transfer these two extremes will not result: A region does not know the probability of the other region and therefore only the cases  $(P_i^l, P_j^m)$ ,  $(P_i^m, P_j^m)$  and  $(P_i^h, P_j^m)$  must be considered.

The probability of different costs is lower for  $(P_i^m, P_j^m)$  but as will be seen the second effect dominates: Type  $h$  regions are most likely to prefer the decentral solution while type  $l$  regions will favor centralization in the largest parameter range.

The decisions about the strategies in the first stage of the bargaining or the delegation game are based on the impact on expected welfare. Without revelation of information expected welfare for a region is obtained by simply applying the probabilities for the different cost structures after receiving the signal  $\sigma_i$  to ex post welfare  $W_i^{t_i t_j}$ . With  $P_i^0$  as the common prior probability and  $P_i^{\sigma_i}$  as the probability when signal  $\sigma_i$  has been observed, we obtain the following formula for expected welfare under decentral policy:

$$EW_i^{\sigma_i}(s_1^{t_1^*}, s_2^{t_2^*}) = P_i^{\sigma_i} P_j^0 W_i^{HH}(s_1^{H^*}, s_2^{H^*}) + P_i^{\sigma_i} (1 - P_j^0) W_i^{HL}(s_1^{H^*}, s_2^{L^*}) + (1 - P_i^{\sigma_i}) P_j^0 W_i^{LH}(s_1^{L^*}, s_2^{H^*}) + (1 - P_i^{\sigma_i}) (1 - P_j^0) W_i^{LL}(s_1^{L^*}, s_2^{L^*}). \quad (9)$$

A similar expression for central policy can be derived easily: We must only replace each  $(s_1^{t_1^*}, s_2^{t_2^*})$  in equation 9 by  $(s^*)$  —  $s^*$  does not depend on the  $t_i$  because the central authority does not know the costs of the regional firms when deciding about the optimal subsidy. In the same manner we obtain the expected welfare of the central authority: For decentralization we must change  $EW_i^{\sigma_i}$  to  $EW$ ,  $W_i$  to  $W$ , and  $P_i^{\sigma_i}$  to  $P_i^0$  and for centralization we must in addition replace the  $(s_1^{t_1^*}, s_2^{t_2^*})$  by  $(s^*)$ .

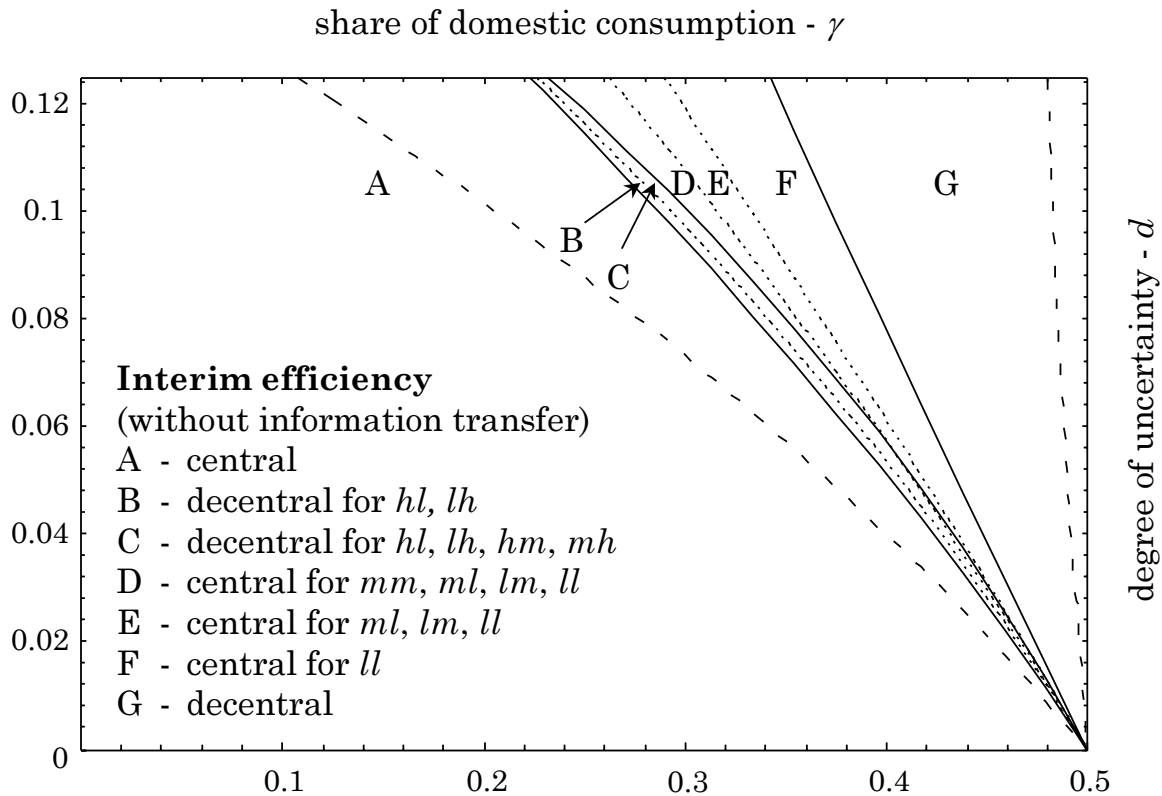
When we observe that bargaining and delegation yield different results, we need some criterion to judge which solution is “better”. The appropriate criterion is “interim efficiency” (see MYERSON, 1991, 485 ff.) based on total welfare: A decision over (de-) centralization is said to be “interim efficient” if  $EW^{\sigma_1, \sigma_2} = EW_1^{\sigma_1} + EW_2^{\sigma_2}$  is maximized. The term “interim efficient” refers to the fact that expected welfare is considered at the time when the private signals are already received but before the actual realization of the equilibrium. This concept enables us to decide whether delegation or bargaining is the preferable mechanism ex ante, i. e. before any private signals are received: This mechanism should be chosen that leads with a higher probability to an interim efficient result. Formally the optimal mechanism maximizes the expected value of  $EW^{\sigma_1, \sigma_2}$  based on the ex ante probability of all possible signal combinations  $(\sigma_1, \sigma_2)$ :

$$E[EW^{\sigma_1, \sigma_2}] = 1/9EW^{hh} + 1/9EW^{hm} + 1/9EW^{hl} + 1/9EW^{mh} + 1/9EW^{mm} + 1/9EW^{ml} + 1/9EW^{lh} + 1/9EW^{lm} + 1/9EW^{ll} \quad (10)$$



By comparing  $EW^{\sigma_1, \sigma_2}$  under central and decentral policy, respectively, we can easily determine the interim efficient policy for each parameter combination  $(\gamma, d)$ . Figure 3 shows the parameter ranges of the interim efficient policy for the various signal combinations (the formulas for the limits of each area can be found in MORASCH, 2003, 178 f.) and additionally displays the borderlines for ex post welfare as broken lines. It is interesting to note that for the largest part of the parameter range — areas A and G — the interim efficient decision does not depend on the signals obtained. Comparing this with the borderlines for ex post welfare we also observe that the interim efficient decision could very well be wrong ex post.

Figure 3: Interim efficiency without information transfer



Source: Mathematica plot based on own calculations

In areas B to F the information obtained is important for interim efficiency.

- In B decentralization is only preferable for signals  $lh$  and  $hl$  — while the expected average cost take only a medium value, the high probability of different costs render central industrial policy unattractive. In C decentralization is also preferable for  $mh$  and  $hm$  — here we have higher expected average costs but the probability of different costs is lower.
- For signals  $hh$  the biggest probability of high costs but costs are also quite likely to be identical and therefore decentralization starts to be interim efficient in D.

- The final two parameter ranges are defined by the borderlines for  $mm$ , for  $ml$  and  $lm$ , and for  $ll$ : In E the decentral solution performs also better for  $mm$ , while in F only signals  $ll$  yield centralization as the superior decision — for  $ll$  there is a high probability for both low and identical costs.

## 4.2 Delegation vs. Bargaining without information transfer

We start with the simplest bargaining setting where it is assumed that no side payments are possible. Thus the strategy space in the bargaining game is given by  $a_i \in \{CP, DP\}$  — a region may either vote for central or decentral policy. The outcome is then determined by the following voting game: Industrial policy is delegated to a central authority if  $(a_1, a_2) = (CP, CP)$ , otherwise the status quo of decentral policy results.<sup>4</sup> Because the central solution will only be chosen if both regions agree there exists a status quo bias, i. e. decentralization is more likely. In contrast the delegation decision by the central government will not be biased. However, in this case the decision is based on the common prior probabilities  $P_1^0 = P_2^0 = 1/2$ , while under the bargaining regime the regions could use the additional information about the likely costs of their firms. Figure 4 shows which decision results as a function of the signals obtained.

First note that for most parameter combinations of  $\gamma$  and  $d$  both mechanisms yield the same decision: In area A industrial policy will be performed by the central authority while in area D decentralization will result. However, if one region obtains a signal  $\sigma_i = h$  this region will block centralization in area B. On the other hand, if the signal for both regions is given by  $\sigma_i = l$ , both will vote for decentralization in area C.

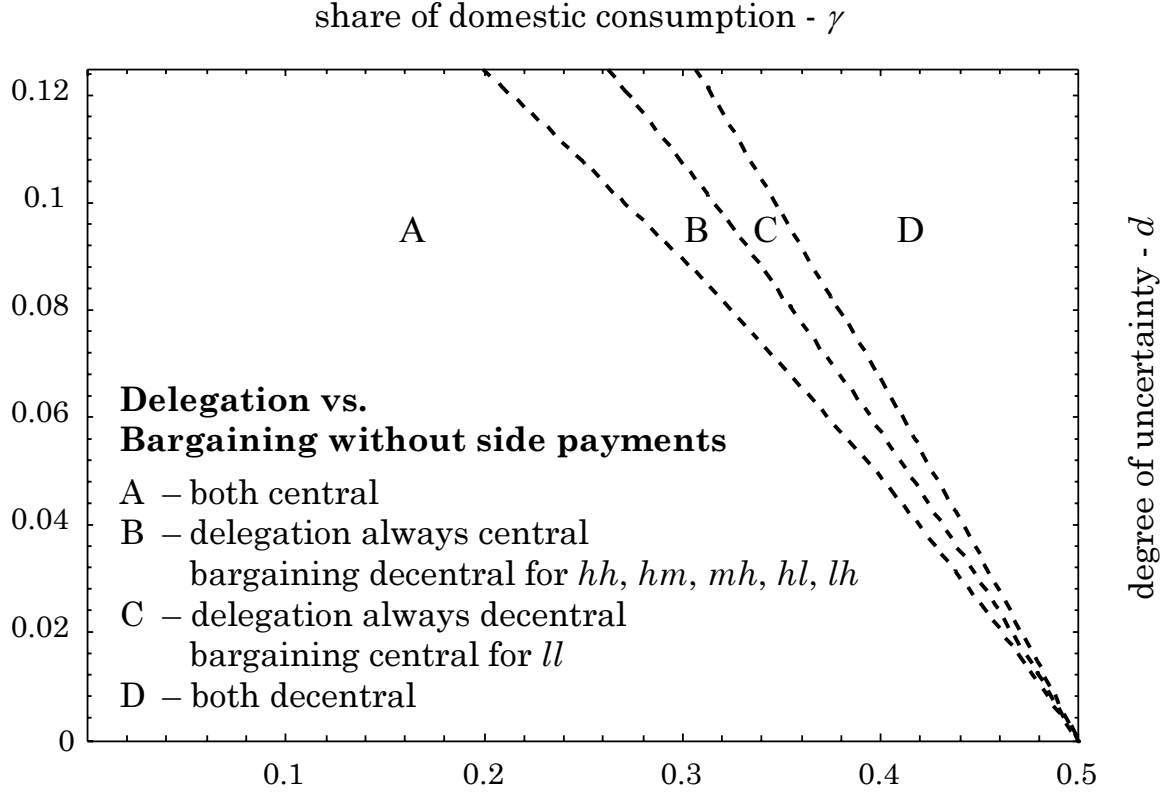
Before dealing with the question whether delegation or bargaining is better in BC and whether interim efficiency is assured in A or D, I will first discuss bargaining with side payments to show how the results are affected by this complication. If side payments are introduced bargaining should perform better: While until now one region might decide against welfare maximizing centralization if expected regional welfare would be reduced, the other country is now able to get the consent in exchange for an appropriate side payment. While this presumption is correct for symmetric information, it may be misleading under imperfect information because type dependent side payments are not possible. Here the result may be inefficient because both parties would like to appropriate the gains from an agreement but, because of asymmetric information, they run the risk of disagreement in order to get a larger share of the pie in the case of success.

The basic aspects of this problem can be seen most easily by assuming a extreme asymmetry of bargaining power: Region 1 makes a “take it or leave it offer” of the form: “I will choose strategy  $CP$  if you also play  $CP$  and give me a transfer payment  $\tau$ . If you reject this offer I will choose strategy  $DP$ .” Region 2 can either accept this offer, play  $CP$  and pay  $\tau$  which yields the central solution or it can reject the offer and decentralization results. This distribution of

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<sup>4</sup>For a discussion of different voting procedures in the context of project approval see SWANK/VISSER (2002)

Figure 4: Delegation vs. bargaining without side payments



Source: Mathematica plot based on own calculations

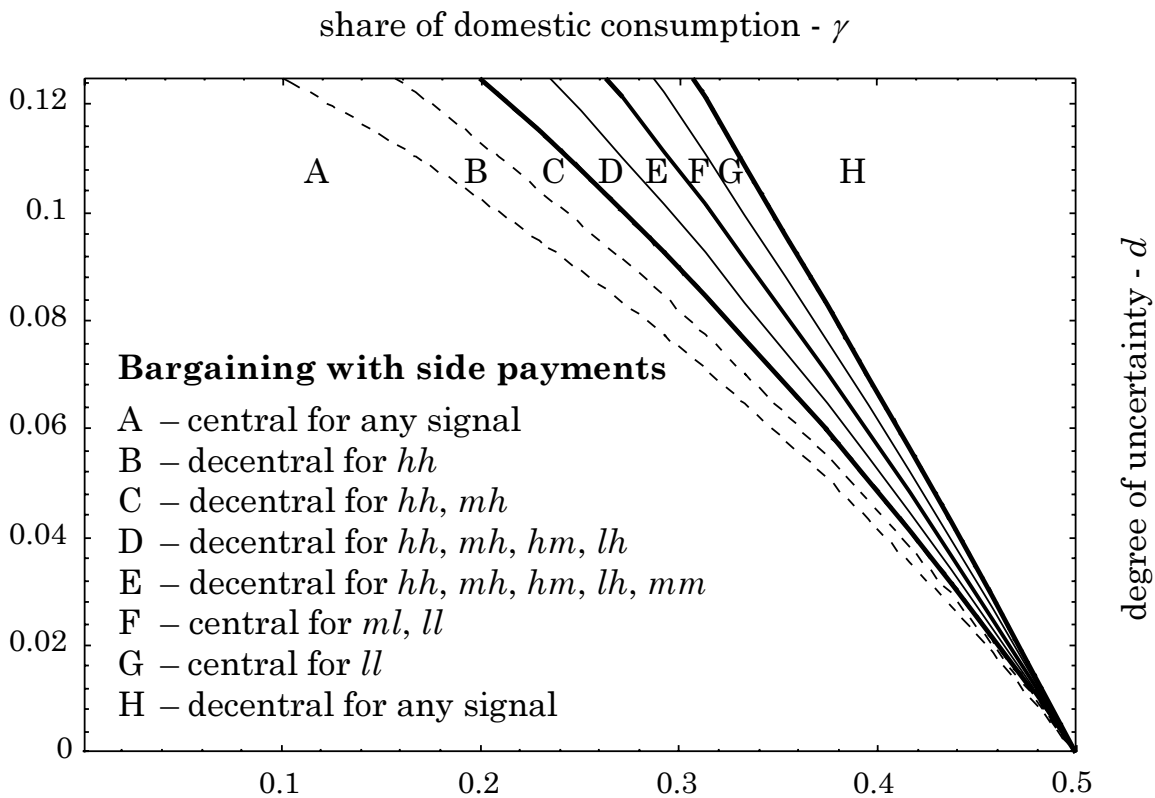
bargaining power is surely unrealistic but the assumption may be defended on two grounds: (i) With both sided asymmetric information a bargaining mechanism which assures in all cases an efficient outcome does not exist (see *Myerson/Satterthwaite (1983)*). The basic problem of bargaining under asymmetric information is thus correctly reflected in the present setting. (ii) Mechanisms with more realistic distribution of bargaining power (e. g. the double auction) are usually plagued by multiple equilibria.

In general, i. e. even if region 1 did not know which kind of signals region 2 might receive, a side payment  $\tau^e$  which equals the difference  $EW_1^{\sigma_1}(DP) - EW_1^{\sigma_1}(CP)$  would assure efficiency in all circumstances: The other region would accept this offer if and only if  $EW^{\sigma_1\sigma_2}(CP)$  exceeds  $EW^{\sigma_1\sigma_2}(DP)$ . However, in this case all gains of an agreement would be appropriated by region 2. When region 1 wants to determine the transfer  $\tau$  which maximizes regional welfare it must consider the value of the central solution for region 2,  $EW_2^{\sigma_2}(CP) - EW_2^{\sigma_2}(DP)$ , for all possible types of region 2. If it wants to assure that the central solution results in any case, the transfer could be at least as large as the value of  $CP$  for a region which received signal  $h$ :  $\tau^h \leq EW_2^h(CP) - EW_2^h(DP)$ . For region 1 the expected welfare gain (including the transfer payment) relative to the decentral solution would then be given by  $EW_1^{\sigma_1}(CP) + \tau^h - EW_1^{\sigma_1}(DP)$ .

This expression is maximized if  $\tau^h = EW_2^h(CP) - EW_2^h(DP)$  (it is optimal to set the highest possible transfer payment which assures that region 2 accepts the offer). Alternatively, region 1 could risk that region 2 rejects the offer if it received signal  $h$ . In this case the transfer payment could be substantially higher because it must only be accepted by type  $m$  and  $l$  regions which have a stronger preference for central policy. The best strategy is then given by  $\tau^m = EW_2^m(CP) - EW_2^m(DP)$ . However, because an agreement is now only reached with probability  $2/3$  the expected gain is given by  $2/3[EW_1^{\sigma_1}(CP) + \tau^m - EW_1^{\sigma_1}(DP)]$ . Finally, a transfer payment could be used which will be accepted only by a region of type  $l$ :  $\tau^l = EW_2^l(CP) - EW_2^l(DP)$ . This yields an expected gain  $1/3[EW_1^{\sigma_1}(CP) + \tau^l - EW_1^{\sigma_1}(DP)]$ .

The problem has now been reduced to choosing a transfer payment  $\tau \in \{\tau^e, \tau^h, \tau^m, \tau^l\}$  which maximizes the expected welfare of region 1 (the reaction of region 2 has already been taken into account). To solve this problem, in a first step it must be determined which of the strategies  $\tau^h$ ,  $\tau^m$  and  $\tau^l$  yield the highest expected welfare. The resulting transfer payment is the equilibrium strategy if it exceeds  $\tau^e$ ; otherwise  $\tau^e$  is optimal (note that whenever strategy  $\tau^e$  is chosen it will lead to decentralization). Results are displayed in figure 5 (for a derivation see MORASCH, 2003, 4.1.3.2).

Figure 5: Bargaining with side payments



Source: Mathematica plot based on own calculations

The solid lines in figure 5 refer to the borderlines for bargaining without side payments. As can be seen the bias towards decentralization has increased. The change may become even clearer by a look at table 1. Here I indicate for each parameter range from B to G which combinations of signal yield different results under bargaining than under delegation (in areas A and H outcomes are identical for all signals). With bold face letters I point out the difference between the situation with and without sidepayments.

Table 1: Bargaining with and without sidepayments — differences to delegation

Parameter-range	Bargaining with side payments	Bargaining without sidepayments	
B	—	<b>hh</b>	
C	—	<b>hh, mh</b>	(bargaining decentral)
D	<i>hh, hm, mh, lh, hl</i>	<i>hh, hm, mh, lh</i>	
E	<i>hh, hm, mh, lh, hl</i>	<i>hh, hm, mh, lh, mm</i>	
F	<i>ll</i>	<i>ll, ml</i>	(bargaining central)
G	<i>ll</i>	—	

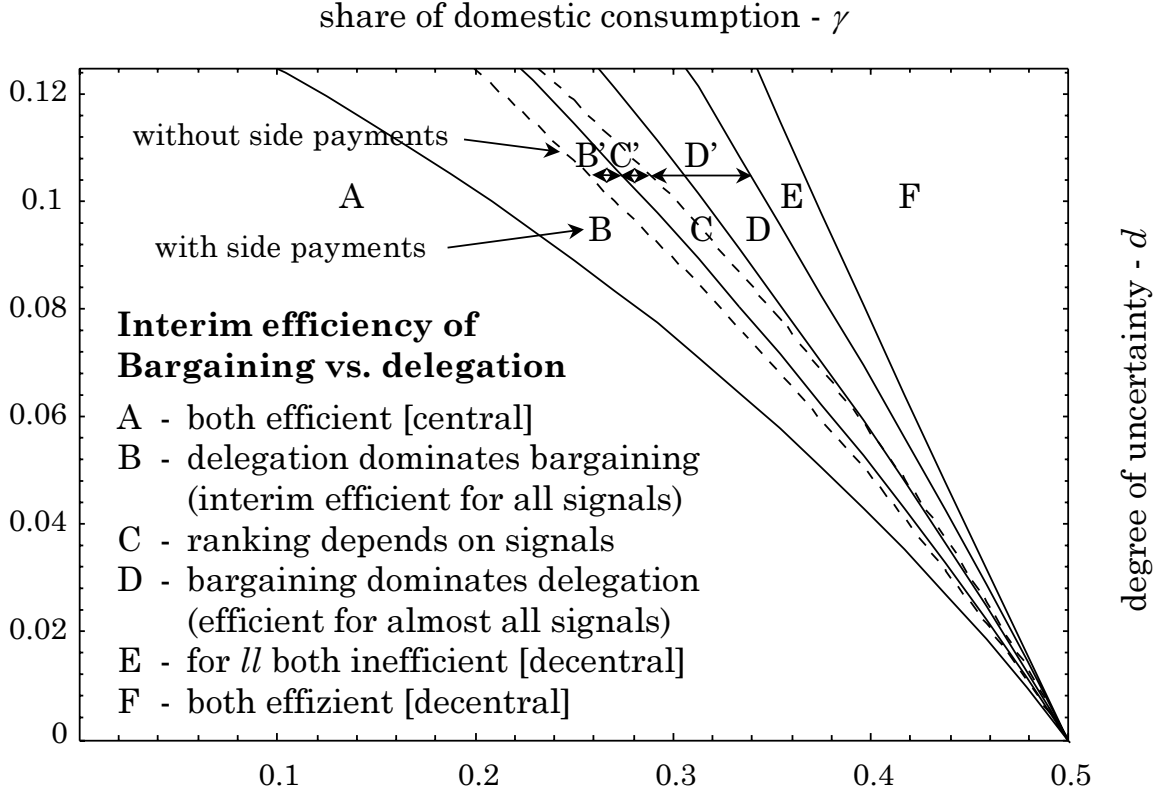
In a further step we will now apply the criterion of interim efficiency and compare the performance of the two mechanisms. Because it is straightforward but quite messy to analyze this question for any signal combination I will only display the main results in figure 6 (again the details can be found in MORASCH, 2003, 4.1.3.2).

As can be seen bargaining without side payments performs at least as good as delegation for the largest part of the parameter space and dominates delegation in the relatively large area D'. Nevertheless there exist parameter combinations (area B') where delegation is preferred. Considering bargaining with side payments, we have a reduced area D where bargaining is better and a greatly enlarged area B where delegation is the dominant strategy. While one would have expected that sidepayments could improve the situation for bargaining, the attempt to get a large share of the expected gains from an agreement deteriorates the performance. In a next step we will discuss whether matters change if information revealed in the bargaining game will be used at the policy stage.

### 4.3 Bargaining with information transfer

If information about the signal  $\sigma_i$  is transferred to the other region or the central government during the bargaining process, the industrial policy will be changed according to this information: Suppose the behavior in the bargaining process indicates that region 2 is either of type  $l$  or  $m$ . Given this the politician in region 1 assigns a probability  $P_j = 3/8$  to the outcome  $c^H$  and the equilibrium subsidies must be computed based on this probability. Formally the

Figure 6: Interim efficiency of bargaining vs. delegation



Source: Mathematica plot based on own calculations

revelation of information will be described as follows: Region  $i$  obtains information  $I_i(\sigma_j)$  about the signal of region  $j$ .  $I_i(\sigma_j)$  can take the values  $\{l, lm, m, mh, h\}$  where for example  $lm$  indicates the information set  $\{l, m\}$ , i. e. that region  $j$  is either of type  $l$  or  $m$ . Specifically  $m$  indicates either a situation with no information transfer or with transfer of information  $\sigma_j = m$  or  $\sigma_j \in l, h$  — all three cases lead to a probability  $P_j^m$  for a high cost firm in region  $j$ . The strategies which result in an equilibrium where information  $I_1(\sigma_2)$  and  $I_2(\sigma_1)$  has been obtained are then denoted  $s_i^{I_1(\sigma_2), I_2(\sigma_1)}$  for decentral policy and  $s^{I_1(\sigma_2), I_2(\sigma_1)}$  for central policy.

With information transfer the analysis becomes much more complicated: When deciding about its strategy, a region must now consider how this strategy would affect the revelation of information about its cost and thus the result at the policy stage. In order to keep the analysis tractable I do abstract from side payments (which would yield a much larger strategy space). In determining the equilibrium the concept of “perfect Bayesian equilibrium” will be applied, which combines the ideas of subgame perfection, Bayesian equilibrium and Bayesian interference: The behavior in the policy stage must be given by a Bayesian equilibrium which is consistent with the posterior beliefs of the players which have been updated in accordance with Bayes’ law (see FUDENBERG/TIROLE (1991, ch. 8) for a detailed discussion of this equilibrium

concept).

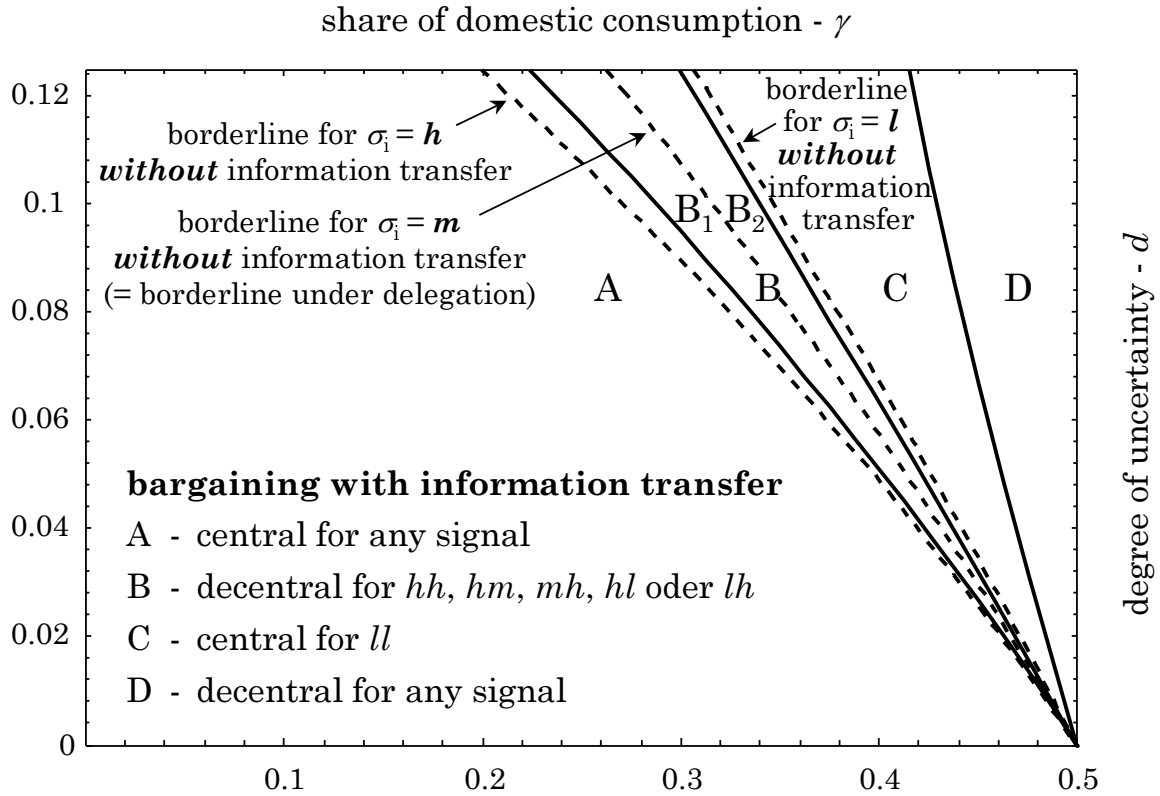
The basic idea of the analysis is straightforward but it is quite messy to check the equilibria for all possible combinations of signals. I will therefore only discuss one example to give an understanding of the procedure and then display the result for all signal combinations in an appropriate figure. So let us consider the decision problem of a firm which received signal  $l$ . From the analysis without information revelation we know that a region of type  $l$  has relatively strong preferences for the central solution. Suppose we are in the parameter range where only a region of type  $l$  would prefer centralization — without information revelation this would be true in the area C in figure 3. What happens if such a region indeed chooses action  $CP$  in equilibrium?

- With probability  $1/3$  the other region is also of type  $l$  and the industrial policy will be performed by a central authority. In the policy stage the central authority knows that both regions are of type  $l$  and will thus impose a subsidy (or tax)  $s^{l,l}$ .
- With probability  $2/3$  the other region received signal  $m$  or  $h$  and thus votes for  $DP$  which in turn leads to decentralization. In the policy stage the other region will be aware of the fact that region 1 observed signal  $l$  while region 1 knows that region 2 is either of type  $m$  or  $h$ . This information structure yields equilibrium subsidies  $(s_1^{l,mh}, s_2^{l,mh})$ .

The expected regional welfare for region 1 if it chooses  $CP$  is thus given by  $1/3 EW_1^{l,l}(s^{l,l}) + 2/3 EW_1^{l,mh}(s_1^{l,mh}, s_2^{l,mh})$ . Note that the preferred solution of region 1 results only with probability  $1/3$ . In the other cases decentralization is the outcome. However, playing  $CP$  has the additional effect that the signal obtained by region 1 is revealed to the other region and the central authority. This revelation of information makes central policy more efficient and is also in the interest of region 1 if decentral policy results because region 2 will reduce its subsidies if the probability of a low cost firm in the other region rises. As shown in figure 7 similar forces are at work in the other cases and thus bargaining is more likely to yield centralization than in the case without information transfer (for details see MORASCH, 2003, 4.1.4). Note that area B is divided in two subareas  $B_1$  and  $B_2$ . This is necessary for comparing bargaining and delegation, because delegation yields centralization in  $B_1$  and decentralization in  $B_2$ .

Delegation dominated bargaining without information transfer for some parameter combinations. We will now deal with the question whether bargaining performs better if the possibility of information transfer is considered. Because the information on the policy stage may no differ between the bargaining and the delegation game, the criterion of interim efficiency is no longer sufficient to determine which mechanism is preferable: (i) Even if bargaining and delegation yield the same decision, the information structure may be different in the policy stage and thus welfare will not be the same. (ii) On the other hand if information about the signals is revealed in the bargaining game, the borderlines for interim efficiency will be different for the two mechanisms.

Figure 7: Bargaining with information transfer



Source: Mathematica plot based on own calculations

Taking this into consideration, a quite messy analysis for any combinations of signals must be performed (again consult MORASCH, 2003, 4.1.4 for details). Based on this analysis we obtain the result displayed in table 2:

Table 2: Bargaining with information transfer vs. delegation

Signals	Parameter range		
	B <sub>1</sub>	B <sub>2</sub>	C
$ll$	(+)	+	[+ * / -]
$lm, ml$	+*	[+ * / -]	(+)
$lh, hl$	+	(+)	(+)
$mm$	(-)*	-*	(-)*
$mh, hm$	+	+	+*
$hh$	-	(+)	(+)

The three parameter ranges refer to these in figure 7: In areas A and D no information is revealed because all types choose centralization or decentralization, respectively; therefore only



areas  $B_1$ ,  $B_2$  and  $C$  are relevant. For these parameter ranges the results for all combination of signals are displayed. Note that a  $+$  indicates that bargaining performs better while  $-$  stands for an advantage of delegation. If a result is also interim efficient this is marked by a  $*$ . Brackets are used if a mechanism is only better due to information transfer and square brackets are set if the relative performance changes within the parameter range. As can be seen, in expectation bargaining performs better than delegation for the whole parameter range and is therefore ex ante preferable:

- In  $B_1$  bargaining yields a superior decision in six cases while in this respect delegation only has a lead for  $hh$ . Each mechanism has an advantage due to information transfer in one case. Note that interim efficiency is only obtained for three signal combinations.
- In  $B_2$  again bargaining yields the correct choice in more cases (3:1) and in addition is superior because of the information transfer in another three cases. Delegation is only preferable for  $mm$  and in  $lm$  and  $ml$  the relative performance changes within the parameter range.
- Finally in area  $C$  the decision under bargaining is correct (and interim efficient) for signals  $mh$  and  $hm$ . In five other cases the information transfer yields higher welfare for this mechanism. Delegation is only better for  $mm$  and for  $ll$  the relative performance changes sign in the relevant parameter range.

## 5 Conclusion

As shown in the literature it often matters whether policy is performed by regional governments or by a central authority. However, an optimal assignment of the decision power is not necessarily assured in practice: A central government may lack information while regional governments which bargain about cooperation may forego efficient agreements for selfish reasons. In the present analysis two procedures, delegation by central government and bargaining by independent regional authorities, have been compared in an industrial policy model. For the case without information transfer it has been shown that bargaining is biased towards decentralization: If no agreement is reached, decentralization results. In spite of superior informed regional government, delegation by the central government may then perform better for a substantial parameter range. Surprisingly, bargaining performs even worse if side payments are introduced: The parties risk disagreement in a situation where all types of regions would prefer centralization in order to appropriate larger gains if the other region has high preferences for central policy. However, if information revealed in the bargaining stage may be used by the other region or the central authority in the policy stage, the situation changes: Here bargaining is preferred in expectation to delegation, i. e., given the probability of the signals, expected welfare is higher under bargaining. Note, however, that this result was obtained in a setting without side payments — it may be possible that bargaining would perform worse if side payments are introduced (this specification has not been tractable in the model).

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