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St. Gallen, May 13, 2009

The President:

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Chapter 1

Introduction
This thesis combines papers on public research funding, unemployment insurance and redistribution in the context of international outsourcing, and job search assistance programs. Although these topics are very diverse, they have one fundamental common feature: they all constitute important areas of public activity. The extent to which these activities are pursued is thus not a direct outcome of private agents’ actions, but they involve a conscious decision by a public entity, here simply called the government. In this process, the government considers the influence of the instruments it has at its disposal on all individuals in the economy, and thus maximizes social welfare.

Another important aspect is given by the fact that these different public activities must all be financed by tax revenues. However, taxes in general influence the behavior of private agents, leading to an excess burden that must be added to the direct costs of an activity. In order to capture both cost elements, we analyze the issues above in very stylized general equilibrium models where the costs of taxation are endogenously determined.

All chapters are self-contained and can be read independently of each other. However, Chapter 2 provides a review of the literature on the topic that is at the heart of Chapter 3, and might therefore provide a helpful introduction if read in advance. Chapters 2, 3 and 5 are single-authored, while Chapter 4 is joint work with Christian Keuschnigg.

The second chapter of this thesis introduces the topic of patenting and licensing activities at research organizations that are traditionally subsidized by public funding. The advent of the knowledge based economy has increased the importance of university research for private sector innovation. In an attempt to improve the technology transfer from academia to industry, many countries have lately assigned the intellectual property rights on research results that were developed with public funding to the research performing institutions. As more and more universities make use of these new regulations, questions arise as to how research and innovation processes are affected. The chapter thus provides a survey of the mainly theoretical insights that have been gained on these issues. It starts out with a discussion of the influence of patenting and licensing on university researchers’ allocation of time across their different missions. It then studies how incentives should be set to secure researchers’ active participation in technology transfer, and discusses the relative advantages of different commercialization forms. We subsequently turn to technology transfer offices, which have been established in
many universities to function as intermediaries between researchers and potential licensee firms, and discuss the different reasons that might rationalize their existence. Last, the chapter considers the implications of patenting of university research on private firms’ innovation decisions.

The third chapter analyzes how public funding of research should optimally adjust when intellectual property rights on research results are assigned to universities. Public research subsidization traditionally follows from the argument that research output provides a public good, as the generated knowledge or techniques can be applied by all interested firms or individuals. By patenting, however, the dissemination of the subsidized research results now becomes excludable and is effectively curtailed to those firms that buy a license. This development thus profoundly affects the rationale for public research funding.

To some extent, licensing also has positive effects. As research institutions can profit financially from their output, they have additional resources available for performing research. The derivation of the optimality criteria for research subsidization shows that license revenues generate a leverage on the public funds devoted to research and are an argument in favor of higher subsidies. The curtailment of access to research results, on the other hand, calls for rather lower public funding. Further influences depend on the form of the license payments that are applied. Whereas the decision of firms to take up innovative activities is not affected if license payments consist of firms’ own equity shares, it is negatively influenced when fixed fees or royalties on output are stipulated as the required payment form. In the case of royalties, the distortion of the prices and consumed quantities of innovative goods provides a further argument for a reduction in research subsidies.

The comparison of the optimality criteria under licensing with the optimal policy when licensing is prohibited shows that public subsidies, and even total research activity by the research organization, are likely to fall when licensing is introduced. Chances for a rise in research activity increase with the marginal cost of public funds in the no-licensing scenario. Due to the fact that the take-up of innovative activities is not impaired under licensing by equity, chances for an increase in research subsidization are strongest in that case.

The fourth chapter turns to the topic of outsourcing of labor intensive parts of production to low-wage economies, which has increased significantly over the
last years in many high-wage European countries. The consequences of this trend are analyzed in a model with heterogeneous workers that replicates important stylized facts of the real world. High-skilled workers face no unemployment risk, have a high labor market income and are also the owners of all firms in the economy. Low-skilled workers, in contrast, can only earn a (lower) labor income and additionally face unemployment risk. The welfare state has two important functions in this framework: first, it provides unemployment insurance to the unemployed low-skilled, which is financed by contributions from the employed low-skilled. Secondly, it redistributes income from the high-income to the low-income workers by means of a linear tax on the labor income of the high-skilled.

The analysis shows that when more firms switch to outsourcing due to a reduction in transport costs, the unemployment risk for the low-skilled is aggravated, and those who remain employed earn lower net wages. General income inequality between the high- and the low-skilled rises. To alleviate the negative consequences for low-skilled workers, the government can in principle raise the unemployment insurance compensation or strengthen redistribution. However, we show that providing more insurance inflates wages and reinforces firms’ incentives to outsource. As a result, unemployment among the low-skilled is further increased. Redistribution, on the other hand, acts as a wage subsidy and thus leads to higher net and lower gross wages, thereby boosting employment. We further show that it is possible to use the tax on the labor income of the high-skilled to distribute the gains from outsourcing in a Pareto improving way if the tax rate is not too high initially. Finally, the chapter also characterizes welfare optimal redistribution and insurance policies in this open economy.

Whereas the fourth chapter shows the employment stimulating effects of wage subsidies, the fifth chapter analyzes job search assistance programs. This activation measure aims at making the job search skills of the unemployed more effective, thus improving their chances to find suitable employment in a labor market affected by frictions. These programs are generally found to be among the most effective active labor market policies for a broad range of participants, and in many countries a large share of insured jobseekers are assigned to attend these programs. In addition to the direct positive implications for participants, their size implies that these programs also have significant macroeconomic consequences, thereby influencing also the welfare of non-participants. These effects must be taken into account when designing the policies.
The chapter thus derives the welfare optimal size and intensity of job search assistance programs. It is found that both characteristics have positive direct effects on participants (or the marginal participants in the case of program size), which follow from the direct stimulation of attendants’ employment probabilities. These effects must be traded off against the program’s net fiscal implications, which must be borne by taxpayers, and against the general equilibrium effects that concern all workers in the economy. These general equilibrium effects consist of the reactions of wages, job search efforts and ultimately employment, and we show that they are also fundamentally related to the marginal net fiscal impact of changes in program size and intensity. For both instruments, the net effect on taxes consists of a positive component in the form of direct program costs and a negative component of an enlarged tax base due to the direct employment stimulation of the policy. We find that when program size and intensity are chosen optimally, the net effect on the labor income tax must be positive at the margin. The required tax increase then also implies that the marginal general equilibrium feedback on aggregate employment is negative and thus counteracts the direct employment stimulating effects of the program.

In addition, the chapter also discusses the conditions when a job search assistance program should be introduced in the first place. We find that the implementation of a small program can increase social welfare only if it sufficiently improves the job finding rates of participants and does not incur too high direct costs already for small numbers of participants. Further, if the general level of taxation is high, for instance due to a generous welfare state, a program is also more likely to improve welfare, as the fiscal gains from the participation tax paid by the additionally employed are then higher.
Chapter 2

University Research, Technology Transfer and Innovation

Evelyn Ribi∗

This literature review discusses the insights that have been gained on the implications of patenting and licensing activities at universities. It first focuses on their effects on faculty researchers’ allocation of time across their different missions. It then studies how incentives should be set to secure researchers’ active participation in technology transfer, and discusses the relative advantages of different commercialization forms. Next, the rationale for establishing technology transfer offices is considered, before we turn to the implications of patenting on firms’ own innovation decisions.

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2.1. Introduction

The transition to a knowledge based economy in industrialized and many developing countries has significantly increased the importance of public research for private sector innovation.¹ Both fundamental and applied knowledge generated by universities and public research organizations are now extensively used by firms in their own innovation processes.² This is especially true in fields belonging to the ‘life sciences’, e.g. medical science and biochemistry, and in information technology. As a result, universities have increasingly been regarded as important players in national innovation systems, and they are expected to contribute to economic growth via the generation of both human capital and new knowledge, information and technologies.

In reaction to these developments, policymakers throughout the world have advocated changes of their countries’ innovation policies. Appropriate reforms should facilitate the technology transfer from universities to industry and in general lead to stronger collaboration between the two groups. Some of these reforms are aimed at stimulating local economic development based on public research. Examples are the creation of science parks located in the vicinity of universities, the provision of seed capital funds and of business incubators (see Mowery and Sampat, 2005b). More general reforms regulate the assignment of intellectual property rights (IPRs) on research results that were developed with public funding. The most prominent legislative act of this kind is certainly the Bayh-Dole Act passed in the U.S. in 1980, but many other countries have concluded similar rulings since.³ As Table 2.1 shows, in many countries the research performing institution and in some cases the researchers themselves are assigned the intellectual property of their scientific output.

As owners of intellectual property rights, the research performing institutions and researchers are also entitled to the financial revenues that might be generated by the licensing or selling of these rights. Many countries have issued guidelines on how these revenues should be shared among the inventor, his department or laboratory, and the university or institution. Most encourage revenues to be split

¹For empirical evidence on the increasing importance, see Branstetter and Ogura (2005).
²In what follows, we use the two terms ‘university’ and ‘public research organization’ interchangeably, unless otherwise indicated.
³There were also other developments in the U.S. before the passage of the Bayh-Dole Act that allowed licensing in certain fields, see Mowery, Nelson, Sampat, and Ziedonis (2001) and Thursby and Thursby (2007a).
fairly evenly between the three parties. In the list of countries displayed in Table 2.1 only Japan assigns 100% of revenues to the IPR owner.

The possibility to generate revenues on their research output thus incentivizes both institutions and researchers to actively engage in patenting and licensing activities. The researchers’ involvement is often crucial due to the nature of the results to be licensed. These are typically at early stages of development, and require further effort by the inventor, even after a licensing contract has been signed, to lead to a marketable product (cf. Jensen and Thursby, 2001). Institutions assist researchers in administrative and organizational matters by setting up technology transfer offices (TTOs). These scan faculty inventions for their licensing potential, file patents, search for potential licensee firms and act on behalf of the university and faculty in licensing negotiations.

Empirical evidence indicates that researchers and institutions indeed react to patenting and licensing opportunities.4 First of all, U.S. universities have strongly increased their patenting activities relative to industry. Over the period 1963-1999, the share of university patents in all domestic-assignee U.S. patents grew from less than 0.3% to almost 4% (cf. Mowery and Sampat, 2005a). During the same period, the number of university patents per Dollar spent on university research more than tripled, see Figure 2.1. The 189 U.S. research universities and public research organizations responding to the annual AUTM (Association of University Tech-

4As most countries have only recently begun to foster licensing activities of their universities, most available data comes from the U.S.
Figure 2.1.
Number of patents per million $ academic R&D expenditures (Source: Mowery and Sampat, 2005a)

Technology Managers) licensing survey reported almost 18’900 invention disclosures and 15’900 patent applications filed in the year 2006 (AUTM, 2007). They were granted 3’255 new patents in the same year, and a total of 4’963 active licenses, of which 39% were exclusive and 61% were non-exclusive, generated aggregate revenues of $1’845 million for these institutions. Apart from licensing inventions to independent firms, university researchers also establish their own companies to bring their inventions to the market. In 2006, 534 such start-up companies were created in the U.S.

In this review, we focus on the implications of these licensing activities on researchers, research institutions and firms. First of all, we address the issue of how researchers’ behavior is affected by the new opportunities. University researchers typically do not only perform industrially relevant research, but are also engaged in teaching and in other, perhaps more fundamental or curiosity-driven research projects. An important question is therefore whether any of these activities will suffer when licensing is possible, and what instruments might be used to influence a researcher’s allocation of time and effort to the different categories.

Section 2.3 looks more closely at the research and technology transfer activities. We discuss the decisions of when inventions should be disclosed and in which way their commercialization should be attempted, distinguishing between established firms and university start-ups. We also address the optimal design of licensing contracts under the different options. Section 2.4 then turns to technology transfer offices, which act as intermediaries between inventors and licensee firms. The
number of offices has increased steadily over the past four decades in the U.S., which raises interest in a theoretical rationale for establishing such intermediaries.

Section 2.5 studies the effects of licensing on firms’ own innovation decisions. Patents alter the appropriability properties of both the university invention and firms’ downstream inventions. They thus influence firms’ R&D decisions, especially in competitive research environments, and also stimulate inventors’ incentives to actively seek commercialization of their inventions. Section 2.6 finally provides an outlook on Chapter 3 of this thesis.

2.2. Researchers’ Time Allocation

A general point of concern often mentioned in discussions of licensing in universities is its effect on the time allocation of faculty researchers. The argument goes that the financial incentives associated with licensing lead researchers to spend more effort on industrially relevant research, thus distracting them from pursuing more fundamental research and from teaching. This will then lead to lower quality education and less basic knowledge produced. Relatedly, some sceptics argue that due to the increasing importance attributed to licensing and the prospect of financial profit, researchers try to commercialize a larger range of their results. The average quality of patents, measured as their applicability in downstream innovation, will thus fall.

Several studies indicate that increasing licensing opportunities have indeed been accompanied by a change in the nature of universities’ patenting activities. According to Rappert, Webster, and Charles (1999), industrial firms perceive a growing commercial orientation in universities. This finding is corroborated by the results of Shane (2004). He examines the fields in which universities are granted patents before and after the passage of the Bayh-Dole Act and finds that after 1980, universities have focused their patenting activities in fields in which knowledge is transferred effectively through licensing.

Henderson, Jaffe, and Trajtenberg (1998) study the importance of patents for private sector research. Their importance measure is the number of citations a university patent receives by subsequent patent applications, and this number is compared to the corresponding measure for a random sample of all U.S. patents. They find that as patenting has increased in universities, the importance of these patents has indeed fallen. However, this result is challenged by Sampat, Mowery,
and Ziedonis (2003), who argue that citation lags for university patents are much longer than for industry patents. When this property is adjusted for, no decline in patent importance can be found.

Mowery and Ziedonis (2002) focus on the quality of patents from universities that newly started patenting after passage of the Bayh-Dole act and contrast them with universities that were already engaged in such activities before 1980. For the latter group, no decline in patent quality is observed, which is in line with the findings of Sampat, Mowery, and Ziedonis (2003) (see also Mowery, Nelson, Sampat, and Ziedonis, 2001). However, universities that began patenting after 1980 file patents that are not significantly more general or important than non-academic patents.

The existing evidence thus indicates that universities try to take advantage of the new patenting and licensing opportunities. Patenting has intensified especially in fields in which licensing proves to be an effective channel for knowledge transfer. The importance of patents for downstream innovation seems to have been unaffected in institutions that already had experience in these activities. Beginners, on the other hand, show signs of patenting results that are less applicable in private sector R&D. It might be the case, however, that as these institutions gain experience and learn how success or financial revenues on a patent are related to its quality, they become more selective in their patenting process.

Increasing patenting and licensing activities naturally beg the question whether basic or rather non-licensable research and teaching quality have declined in the process. Agrawal and Henderson (2002) study the patenting and publication behavior of MIT faculty and find a positive correlation between the two activities. This finding is confirmed by Stephan, Gurmu, Sumell, and Black (2007) for the larger sample of almost 11’000 doctorate recipients at U.S. institutions in 1995. Both studies, however, only consider the quantitative measure of total publications by researchers and do not distinguish between basic and applied contributions. They can thus not capture an eventual change in the research focus. Thursby and Thursby (2007b) address this shortcoming by weighting publications by an index measuring their basicness. Studying the behavior of over 3’200 science and engineering faculty researchers in the U.S. over the period 1983-1999, they find that the share of basic research published did not alter over the period, although researchers’ probability to disclose inventions (as a first stage towards a patent) grew by a factor ten.

Azoulay, Ding, and Stuart (2006) study both quantitative and qualitative publication measures of almost 3’900 researchers from biomedical fields. Quality indica-
tors come from the citation impact factors of the respective journals. Their data also indicate that patenters publish more articles than non-patenters, but there is no significant difference in the quality of publications between the two groups. The empirical evidence thus suggests that patenting and publishing go hand in hand, and some studies even imply that publications are a precondition for patenting. As of yet, there is no confirmation found in the data that basic research will indeed suffer from licensing.

A few theoretical papers have also addressed the influence of licensing on researchers’ other missions. Jensen and Thursby (2004) develop a framework in which the university administration is the principal, deciding on a researcher’s teaching load and salary. The researcher, as the agent, allocates the remaining time to basic and applied research to maximize his utility, which depends on income and on prestige. Both types of research contribute to basic and patentable knowledge, and applied research additionally generates license revenues for the university and the researcher. If the relationship examined lasts only for one period, the model implies that the researcher would reallocate his time in favor of applied research. However, in a dynamic setting, today’s research influences the stock of knowledge available in the future. As investments in basic research also lead to more patentable knowledge, it is unclear whether licensing would reduce the researcher’s time allocated to this activity.

Thursby, Thursby, and Gupta-Mukherjee (2007) study researchers’ efforts in basic and applied research over their whole life-cycle. They have a fixed teaching load as well, but determine their overall work effort endogenously. In this framework, although licensing increases the ratio of time spent on applied research relative to basic research, scientists reduce their leisure time so much that total effort devoted to basic research might even increase. In addition, when applied research also produces publications, then total research output and the stock of knowledge are higher with licensing than without. It is also shown that in a tenure system, basic research effort is very high early in the career. Licensing is then likely to reduce basic research effort in this stage, but increases it after tenure has been granted. This pattern of high basic research output early in the career and subsequently high levels of patenting and licensing activities is confirmed empirically by Azoulay, Ding, and Stuart (2007).

The share of license income a researcher receives is an important instrument at the disposal of university administrations to influence faculty’s efforts in the different research categories. Beath, Owen, Poyago-Theotoky, and Ulph (2003) show this
in a principal-agent model with university researchers engaging in basic and applied research. They receive a share of the license revenues that are generated on applied research, the remaining share is appropriated by the university which employs additional researchers out of these revenues. The authors show how the university administration can induce researchers to generate a desired amount of basic knowledge by determining their share of license income appropriately. The fears that licensing will seriously damage basic research incentives and lead to a deterioration in fundamental knowledge are thus not supported by empirical evidence, and theoretical considerations quite clearly imply a growth in total research activities, and possibly also in basic research effort. A common drawback of existing models is that they do not give any implications on if and in which direction teaching loads should be adjusted with licensing, and there is to this date also no empirical analysis on the interaction of licensing and teaching activities.

2.3. Commercialization and Optimal Contracts

The process from a new invention to a commercial product includes several critical decisions. First of all, a researcher has to determine at which stage he wants to disclose an invention. Disclosure is typically done vis-à-vis a technology transfer office, which then starts the patent application process and looks for potential licensees. However, researchers can also try to commercialize their inventions in their own start-up firms. When a licensee is found, the firm, the researcher and the university have to agree on a contract stipulating potential further involvement of the researcher in the project and the payment of a license fee.

The issue of the optimal disclosure time of university inventions has not received much attention in the existing literature. One exception is the paper by Lacetera (2008), which compares the commercialization decisions of university scientists to those of industry scientists. He studies the situation of a research team that can either try to commercialize a given invention right away, or pursue further research that might reduce the costs of commercialization in the next period. In contrast to an industry research team, academic researchers derive utility from doing research per se and have a higher cost to increase the applicability of their research. Consequently, ex ante expected revenues from a project must be higher for university researchers to start commercialization. However, when academics’ costs of doing additional applied research are very high, they start commercialization activities before an industrial team. This finding thus implies, for instance,
that academics who have a high publication potential in basic research, and thus a high opportunity cost of applied research, would disclose their inventions earlier than others with lower publication potential.

Jensen, Thursby, and Thursby (2003) study disclosure in a model where a TTO acts as the link between a faculty researcher who can disclose his research results at different stages and firms that need those patents for commercial products. Whereas the researcher is an agent of the university administration, the TTO is an agent of both the administration and the researcher, which is confirmed by empirical tests. The model shows that faculty quality influences the time at which an invention is disclosed, but the sign of the relationship is ambiguous. In an empirical examination of disclosure activities at 62 U.S. research universities, they find that higher quality researchers are more likely to disclose their inventions at a very early stage. This result thus connects well with the implications of Lacetera’s model discussed above.

Jensen and Thursby (2001) report the stages of development at the time a license is executed for all licensed inventions of the universities studied also in Jensen, Thursby, and Thursby (2003). They find that 48% of the inventions were at the proof of concept stage, without a prototype created yet. 29% had developed a lab-scale prototype, while for 30% there was either some animal data or some clinical data available. Only in 12% of the cases was the invention ready for practical or commercial use, and in 8% more the manufacturing feasibility was at least known. The most striking result, however, is that in more than 70% of all licensed inventions, the cooperation of the inventing university researcher was required in subsequent development. Agrawal (2006) examines empirically how ongoing involvement of the inventor and his graduate students contributes to the success of an innovation project. He finds that the likelihood of commercial success as well as the level of royalty revenues flowing to the university are positively correlated with the number of hours the inventor spends on the project after the licensing contract has been signed.

In light of this evidence it is of great importance that licensing contracts, apart from specifying the price of a license, set the proper incentives to secure a university researcher’s further involvement in a research project. This can for instance be done by tying his license revenues in some way to the success of the project. Jensen and Thursby (2001) examine this issue in a model in which a project’s success probability depends on the inventor’s effort, which is not observable by the licensee firm. They analyze two different reward structures that might alleviate
the ensuing moral hazard problem: a royalty rate on output versus an equity share in the firm. Both payment forms can be combined with a fixed fee. Clearly, a positive royalty rate or equity share are necessary to induce a positive effort of the inventor. While a higher equity share also raises effort, an increase in the royalty rate does so only to the extent that it actually raises licensing revenues. As a higher royalty rate reduces a firm’s output, total licensing revenues are typically hump-shaped in the royalty rate. A comparison of the two financial reward structures shows that licensing by equity is more efficient than licensing by royalties if a firm’s maximal profit from a successful invention is decreasing in the royalty rate. Giving researchers an equity stake in the project or firm that is based on their inventions is now generally perceived by universities as an effective way to align researchers’ and firms’ interests (Feldman, Feller, Bercovitz, and Burton, 2002). Universities also value the possibility to partake in the full revenue potential, while firms benefit from positive reputational effects which attract other investors. In the most extreme form of licensing by equity, inventors establish their own start-up firm to commercialize their ideas. Lowe (2002) discusses case studies on university start-ups at the University of California. As the intellectual property of faculty inventions lies with the university, inventors first have to buy a license back from the technology transfer office. The fact that the inventor’s tacit knowledge was crucial for further development is found to be an important reason for the decision to try commercialization in start-ups, as contracting with other firms would have been too difficult in this situation. In an analysis of MIT inventions, Shane (2002) identifies the effectiveness of patent protection in the specific technological field of an invention as a key determinant of whether the invention will be licensed by a start-up or an established firm. He offers the explanation that without effective patent protection, transaction problems between the inventor and the licensee will be severe, leading to a strong moral hazard and hold-up problem. Development by the inventor is thus more attractive, as it circumvents these transaction problems. Tacit knowledge also emerges as a crucial factor in the theoretical model developed by Lowe (2006). In projects with a large tacit content, it is comparatively easy for the inventor to gain full monopoly profits when he does development himself. Conversely, if an invention’s tacit content is only moderate, ordinary licensing becomes more profitable, especially for researchers with a high opportunity cost of their effort. In Di Gregorio and Shane (2003), the hypothesis that financial considerations play an important role is also confirmed empirically. As an inventor’s share of royalties
in ordinary licensing agreements decreases, more inventors opt for commercialization in their own start-ups. A further factor that increases the probability of licensing in a start-up is the availability of venture capital (Chukumba and Jensen, 2005; Powers and McDougall, 2005). The need for outside financing is incorporated into a model developed by Macho-Stadler, Pérez-Castrillo, and Veugelers (2008). They analyze the optimal contract between an inventor, a technology transfer office that owns the disclosed invention, and a venture capitalist. Securing the inventor's further development effort requires assigning him founder shares. If the moral hazard problem is particularly severe, it might be necessary that he invests his own funds in the project to provide sufficient incentives. An interesting result pertains to the role of the TTO: if it has better information regarding the success probability of the project, it will itself take a financial stake in the venture to signal its quality to outside investors. Studying start-up activities in the U.S. over the last two decades, Lerner (2005), however, argues against universities investing internal funds in faculty start-ups. As internal funds often come with strong regulatory ties, they induce higher costs and restrict the investor's discretion in decision making, and very often reduce the success probability of a project.

A further point of interest is the performance of start-ups in the market. Lowe and Ziedonis (2004) find that time to commercialization in a newly founded firm is comparable to established firms. However, revenues flowing from the start-up to the university are, on average, higher than those from ordinary licensing (see also Bray and Lee, 2000). Most successful start-ups do not remain independent, though, but are at some point in time acquired by an established firm. This often happens even before commercialization of the initial project has been terminated.

2.4. Technology Transfer Offices

In response to the growing opportunities to patent and license inventions, universities in the U.S. have increasingly set up technology transfer offices since the last 1970s, see Figure 2.2. They function as intermediaries between inventors and firms that potentially want to buy a license to the patented invention. A few empirical studies have analyzed the efficiency of TTOs in generating licenses and license revenues. For TTOs of U.S. universities, Siegel, Waldman, and Link (2003) find a positive relationship between the number of TTO staff and the number of licenses generated, but TTO staff had no significant impact on licensing revenues. Quite
contrarily, spending on external lawyers results in higher revenues, at the cost of a lower number of license agreements. This goes well together with the observation that external lawyers bargain more aggressively than university administrators. TTOs in states with high levels of industrial R&D are also found to be more efficient, pointing to the importance of spatial vicinity, and thus greater opportunities for personal contacts, for the success of licensing negotiations. Thursby and Kemp (2002) find evidence that private universities are more efficient in generating revenues than their public counterparts. As to be expected, applied fields like biological sciences and engineering contribute more to licensing activities than the more fundamental physical sciences. In the U.K., where licensing is still less prevalent than in the U.S., Chapple, Lockett, Siegel, and Wright (2005) find substantial heterogeneity in TTO performance, and significantly lower levels of average efficiency. In line with Siegel, Waldman, and Link (2003), they also stress the positive effect of regional R&D on university technology transfer.

The issue remains why universities install technology transfer offices in the first place. It is conceivable that an inventor writes a patent application himself, and then looks for and negotiates with a licensee, without the need for an intermediary. However, in reality, most universities that are serious on technology transfer set up separate offices. Potential explanations focus on informational aspects regarding the inventions. Hoppe and Ozdenoren (2005) assume that relative to firms, a TTO is better in detecting the profitability of an invention. By having an expertise done at some cost, it gains full information on the true quality of an invention. Although this creates asymmetric information between the TTO and the firm, the use of success-based license payments can induce the TTO to license a higher share of
high-quality inventions in equilibrium, if the TTO has access to a sufficient number of inventions. This raises expected profits for firms, and can make it profitable for them to pay for intermediation.

Similar reasoning is applied by Macho-Stadler, Pérez-Castrillo, and Veugelers (2007), where by shelving low-quality inventions, the TTO can over time build a reputation for offering only inventions above a certain quality threshold. The shelving of low-quality projects leads to fewer but more valuable inventions being sold at higher prices.

2.5. Innovation in Firms

So far, this literature review has focused on the incentives for and implications of technology transfer within universities. An equally important factor are the firms that license inventions from universities. In this section, we thus look at how the innovation process in firms is affected by licensing.

A lot of criticism of legislative changes that allow patenting and licensing at universities is focused on the ensuing excludability of the respective knowledge (see for instance David, 1998, 2004). Research results that would previously have been available for everyone can now, for the duration of the patent, only be used by firms willing to buy a license. If licensing is exclusive, i.e. the patented invention is only licensed to a single firm, the curtailment of dissemination is particularly severe. Being aware of these problems, policymakers increasingly try to restrict exclusive licensing. In the U.S., there are several institutions that rule out exclusive licenses for certain types of inventions (e.g. research tools), or promote easier access for specific groups of licensees (see Thursby and Thursby, 2007a). Still, also non-exclusive licensing is likely to reduce the range of application of inventions, so the effects of excludability cannot be ignored.

One aspect of excludability is that it makes returns to the invention and to subsequent downstream innovation by industrial firms appropriable. In a situation where the products of industrial research per se are not patentable, licensing of university inventions thus has strong implications for firms. Buying a license de facto makes their own innovation appropriable, and thus provides an substantial advantage relative to competitors. Mazzoleni (2006) studies whether in such a situation, licensing of a given university invention might increase overall R&D performed in the industrial sector. He argues that only in cases in which the threat
of imitation is very strong and when product market competition must be expected to be severe, will (exclusive) licensing stimulate industrial R&D. This also implies an increase in social welfare due to higher consumer surplus. However, it is also possible that licensing raises social welfare in the situation where industrial innovation can be patented. Suppose open access to university inventions results in a patent race among firms, thus leading to wasteful R&D investments. As the number of competitors is then reduced by licensing, the decrease in R&D might increase welfare despite lower consumer surplus.

In contrast to Mazzoleni (2006), Hellmann (2007) analyzes the implications of appropriability of the university invention itself. He assumes that the process of matching inventions to licensee firms is affected by frictions. Both inventors and firms thus have to engage in costly search activities to find a suitable partner. When the invention cannot be patented, the firm can appropriate most of the value of the invention after the researcher has disclosed it. His bargaining power is then directly related to the amount of tacit knowledge he has on the invention. This situation leads to low incentives to search for an licensee firm in the first place. Patenting, however, can overcome this problem as the invention now clearly belongs to the researcher (or the university), and stimulates his search effort unambiguously. Unfortunately, firms’ search effort analogously falls, as their returns to searching are now diminished. The time to market for a particular invention might thus rise or fall with licensing.

In general, the length of a patent determines for how long a patented invention is protected from imitation. Unless diffusion time is by nature very long, e.g. due to a large share of tacit knowledge involved, patenting increases the time lag until inventions can freely disseminate in the market. Bhole (2006) shows that when this increase is large enough, patenting leads to more direct collaboration between firms and universities. This way, firms can gain early access to the specific invention and thus obtain an advantage over their competitors.

2.6. Outlook

Existing studies on the technology transfer from academia to industry mostly focus on researchers’ and firms’ incentives to engage in these activities. What has not received much attention in the discussion so far is how patenting might feed back on research subsidization in universities. The traditional argument for public research funding, going back to Nelson (1959) and Arrow (1962), follows from
the public good properties of universities’ research results. However, as patenting makes the respective invention excludable, the rationale for public research funding is altered as well. Chapter 3 of this thesis provides a first analysis of the implications of licensing on optimal public research subsidization. In the initial situation, firms can freely use university inventions to reduce their own innovation costs, and the state subsidizes the non-rivalrous and non-excludable research optimally. When licensing is introduced, dissemination of research results is reduced to firms that buy a non-exclusive license. On the other hand, licensing provides the university with additional revenues that can be spent on the patented invention, thus ceteris paribus increasing its effectiveness. The paper studies how optimal research funding should be adjusted under different forms of license payments, focusing on fixed fees, equity shares and royalties on firms’ output. It is found that in all three cases, the arguments for a reduction in public research funding seem likely to be dominant, unless the social costs of public funding are very high in the initial situation.
Chapter 3

Licensing and Optimal Public Research Funding

Evelyn Ribi *

As university research becomes increasingly important for innovation processes in industrial firms, many countries newly assign intellectual property rights on publicly subsidized research to the research performing institutions. This enables these institutions to profit financially from their research results and provides additional resources for performing research. On the downside, patenting curtails the dissemination of research results to those firms that buy a license. These effects profoundly affect the rationale for public research subsidization. This chapter analyzes how optimal public research funding should adjust when patenting and licensing are possible. We consider the three most prevalent forms of license payments, i.e. fixed fees, equity shares and royalties. We find that in all three cases, the arguments for a reduction in public subsidies seem to be dominant, and even total research activity is likely to decrease. Among the three options, licensing by equity promises to have the most favorable effect on total research activity.

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3.1. Introduction

Over the last decades, industrial innovation has relied more and more heavily on scientific research performed in universities and other public research organizations.¹ This is especially true in fields like engineering and applied sciences, but holds also for the more basic sciences like mathematics, physics and chemistry (Mowery and Sampat, 2005b; Cohen, Nelson, and Walsh, 2002). At the same time, in several countries universities have been newly entitled to the intellectual property rights of the inventions resulting from publicly funded research. The most prominent legislative act of this kind is the Bayh-Dole Act from 1980 in the U.S., but many other countries, among them Canada, Denmark, Germany and the UK, have passed similar rulings since (see OECD, 2003).² Universities are thus granted patents on their inventions developed with public funding and can generate more revenues by selling licenses to use their inventions to industrial firms.

Empirical evidence illustrates that universities indeed react strongly to the new opportunities. In the U.S., university patents per R&D Dollar have increased more than threefold in the three decades after 1963 (Mowery and Sampat, 2005a). Further, the total share of patents held by universities in all domestic-assignee U.S. patents has increased from less than 0.3% in 1963 to almost 4% in 1999. These developments reflect a growing propensity in universities to patent their research results and are also a sign for the increasing importance of scientific research for industrial innovation. Eventually, universities’ desire to benefit financially from their inventions has led to nearly 5’000 active licenses being held by the 189 U.S. research institutions responding to the Association of University Technology Managers’ annual survey in 2007 (see AUTM, 2007). Aggregate license revenues amounted to $1’845 million for these institutions.

Proponents of these policy changes that assign intellectual property rights on publicly funded research to universities stress that they provide incentives for universities to actively engage in technology transfer and to pursue more research in fields that are relevant for industry. This should then stimulate innovative activity in the private sector and increase a country’s growth potential. An important drawback, however, is that through patenting, technologies and knowledge that previously had the properties of a public good now become excludable. For the

¹We use the terms ‘university’ and ‘public research organization’ synonymously in what follows.
²In a recent publication, the EU Commission also emphasizes the advantages of a single European ownership model for publicly funded research and stresses its determination to work towards a coherent policy across European countries (cf. EU Commission, 2007).
duration a patent is valid, the range of firms which can apply the respective invention is thus curtailed to those that buy a license.

Several aspects of these arguments have been analyzed in the theoretical literature on technology transfer (see Section 3.2). Most attention has been directed towards the incentives for both inventors and industrial firms to engage in technology transfer, and to the interaction of these activities with other core missions of researchers. What is not considered in the literature on university licensing so far, is how the government should optimally adjust its own research subsidization policy. This is the topic of our paper.

The traditional argument for public research funding, going back to Nelson (1959) and Arrow (1962), follows from the assumption that research results have the properties of a public good. As patent protection leads to the excludability of inventions or technologies, the rationale for public subsidization of the respective projects is also altered. It must therefore be expected that public research funding should be adjusted when licensing is possible. We examine how the optimal subsidy should be determined with licensing, and in which direction optimal research activity is likely to change.

To this end, we incorporate a public research organization into a general equilibrium framework with innovative firms. The organization pursues research projects leading to a technology that can be used by firms to reduce their own innovation costs. When the organization has no intellectual property rights on its output, the technology is freely available to firms and has the properties of a public good. Once patenting and licensing is possible, the research organization can generate additional revenues by selling licenses on its technology to firms. We assume throughout the paper that only non-exclusive licenses are applied, which is in line with empirical observations for this category of inventions (see Thursby and Thursby, 2007a). The basic version of the model considers uniform, fixed fees across firms; but we also study equity shares of firms and royalties per unit of output as different forms of license payments. According to Jensen and Thursby (2001), these three categories are the most prevalent payment mechanisms stipulated in licensing contracts between universities and firms.

We find that under all three licensing forms, the curtailment of the dissemination of the technology provides a first argument for reducing public funding of a research project. A second argument follows from individuals’ role as firm owners: as the research organization demands higher license payments with increasing
public funding, this leads to a fall in firms’ net profits that can be transferred to households. In the cases of licensing by fixed fees and by royalties, the license payment also negatively affects the market entry decision of innovative firms: a given increase in the effectiveness of the technology only leads to a smaller rise in the number of firms compared to the no-licensing scenario. In contrast, when licenses are paid for by an equity share in the firms, the entry decision of the marginal firm remains unaffected.

These reasons for a reduction of public research funding are opposed by the fact that license revenues increase the organization’s resources and stimulate further research. The payments thus provide a leverage on public funds, and, for a given level of the public funding, the resulting technology becomes more effective in reducing firms’ innovation costs. The comparison of the optimality criteria under licensing with the optimal policy when licensing is prohibited shows that public subsidies, and even total research activity by the research organization, are likely to fall when licensing is introduced. Chances for a rise in research activity increase with the marginal cost of public funds in the no-licensing scenario. They seem to be most favorable in the case of licensing by equity, as the market entry of innovative firms is then not impaired by the license payment.

Specifically comparing licensing by fixed fees and licensing by equity, we find that if the research organization can freely choose the license form it wants to apply after it has received the transfer, it will charge fixed fees, leading to higher research activity and prestige. As the government anticipates this behavior, it will set the transfer accordingly. However, if a specific license form could be tied to a transfer, the research organization would actually prefer licensing by equity shares.

After presenting the most relevant related literature in the next section, we introduce the model and analyze the equilibria without licensing and with licensing by fixed fees in Section 3.3. Section 3.4 extends the analysis to alternative specifications of license fees, i.e. equity shares and royalties on output. Finally, Section 3.5 concludes. The Appendix contains some more technical calculations and proofs.

3.2. Related Literature

In recent years, technology transfer from academia to industry has drawn wide attention and led to a substantial body of literature. Most existing studies are empirical and focus on the effectiveness of technology transfer as a function of
the characteristics of the involved parties. Agrawal (2001) provides an excellent review of such studies performed until 2001, while Phan and Siegel (2006) focus on the more recent literature. Here, we only summarize the findings that are most important for our paper.

Empirical evidence clearly indicates that academic science has become more important for industrial research in recent years. This is to a large part due to the fact that research and innovation activities have substantially increased in fields that could be summarized by bioscience, in which they have traditionally had a close link. However, Branstetter and Ogura (2005) also find support for the hypothesis that the nature of innovative activity in firms has changed. Today, there is a stronger emphasis in firms on the use of knowledge or technologies that have been developed in academia.

There are also several different forms in which the output of academic research reach the private sector. Cohen, Nelson, and Walsh (2002) distinguish between three categories: research findings, prototypes, and instruments and techniques. Analyzing data from the Carnegie Mellon Survey on Industrial R&D in 1994, they find that for 29.3% of R&D projects undertaken by the surveyed firms, research findings were considered useful. 22% of industrial R&D projects made use of instruments and techniques developed by public research organizations in their own R&D process, and only 8.3% used prototypes. If these findings carry over to the whole industry, this corresponds to an annual average of $26 billion worth of industrial R&D using research findings and an average of $20 billion applying instruments and techniques from university research (see Cohen, Nelson, and Walsh, 2002). The formulation of research results we use in our model includes the instruments and techniques category and the share of research findings that can be licensed non-exclusively and do not need much further development before they can be applied by industry.

Compared to the empirical studies, theoretical research on the consequences of property rights on public research is less extensive. Several studies analyze the incentives of researchers to engage in technology transfer, and how further involvement by the inventor can be induced by an appropriate design of contracts (cf. Jensen and Thursby, 2001; Lowe, 2006; Macho-Stadler, Pérez-Castrillo, and Veugelers, 2008). A few papers consider the implications of patenting and licensing on innovation decisions in firms, a point that is very important also in our analysis. Bhole (2006) argues that unless diffusion time of research results is by nature very long, patenting increases the time until the respective results are freely
available in the market. If this increase is high enough, patenting will lead to more direct collaboration between firms and universities, as this guarantees firms early access to an invention.

Other studies take it as given that patenting leads to a substantial increase in the diffusion time of inventions. Patenting then has the effect that the research results become appropriable. Hellmann (2007) studies how this affects dissemination when the process of matching inventions to licensee firms is affected by frictions. As patenting increases the share of an invention’s value that the researcher can secure for himself, he has stronger incentives to search for a potential licensee and engage in technology transfer. Firms’ own incentives to search for a useful invention are, however, affected in the opposite way. It is therefore unclear whether patenting increases or rather reduces the dissemination of research results.

Apart from the effect on the patented invention itself, patenting also has implications on the appropriability of downstream innovation in firms. This issue is analyzed by Mazzoleni (2006). He argues that even if downstream innovation is not patentable, intellectual property rights on an upstream university invention make industry R&D de facto appropriable. This has strong effects in a competitive R&D environment which is typically characterized by severe hold-up problems. Patenting can then even increase industrial research and social welfare.

A common drawback of the discussed studies is that they take the nature and rate of university inventions as given. They do not consider that patenting and licensing also alters the rationale for public research funding, and how the government should optimally react to such a policy change. These issues will be analyzed in this paper.

3.3. The Model

To study the issues outlined above, we develop a one-period general equilibrium model of a closed economy with two consumption good sectors. In the traditional sector, competitive firms produce a homogeneous good by applying a Ricardian technology with a unit labor coefficient. The gross wage rate is therefore fixed to one. Firms in the innovative sector produce each one specific variety of innovative products and sell them monopolistically. However, before production can take place, they must develop blueprints on their respective product ideas, which incur idiosyncratic costs.
The economy contains a public research institute that pursues its own research project. The project leads to a technology which private firms can use to reduce the necessary investments in their innovation process. If the institute holds no intellectual property rights to its research results, the technology has the properties of a public good. The institute’s sole source of revenues is then a research subsidy from the government. Once the institute is granted intellectual property to its output, it can increase its budget by selling licenses to innovative firms to use the technology. We assume throughout the paper that the institute only sells non-exclusive licenses. Empirically, this licensing form is very common. In 2006, 61% of all licenses issued by U.S. universities were non-exclusive, and several funding institutions have issued guidelines that strongly recommend non-exclusive licensing for certain types of inventions, e.g. for research tools (cf. AUTM, 2007; Thursby and Thursby, 2007a). As the technology we specify in the model is in nature very close to a research tool, the assumption of non-exclusive licensing is appropriate. In the basic version of the model analyzed in this section, we assume that the institute charges all licensee firms a uniform, fixed fee when it has the right to patent its research results. The situation where licensing is prohibited then follows naturally by imposing a zero fee.

The individuals populating the economy are all identical. They jointly own all firms and are therefore entitled to an equal share of aggregate profits. At the same time, they are also workers with endogenous labor supply. Labor income is taxed by the government to finance the transfer to the research institute. In the determination of tax and transfer levels, the government is guided by its goal of social welfare maximization.

Due to the nature of interactions between the different agents, the following sequence of events emerges: At the beginning of the period, the government determines the level of research funding and the level of the labor income tax. Firms in the traditional sector hire all workers, who supply their chosen amount of labor. Tax payments are then transferred to the research institute as a lump-sum subsidy. The institute purchases the desired amount of the traditional good and generates research output. This determines the effectiveness of its cost-reducing technology. Subsequently, firms in the innovative sector know the cost for developing a blueprint for their particular product version. They decide on entering the innovation stage and on applying the institute’s technology in the process. After completing development, they buy traditional goods and transform them

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3We consider equity shares and royalties in Section 3.4.
into innovative products. Finally, consumption takes place. In consequence of the sequential nature of decisions, the model is solved by backward induction.

### 3.3.1. Consumption and Labor Supply

Individuals are hired by the traditional sector and supply an amount of labor \( l \) endogenously. As the traditional good is the numeraire, they earn a gross wage rate of \( w = 1 \), which is taxed at the proportional rate \( t \). In addition, they jointly receive aggregate profits \( \Pi \) generated by all firms in the economy. With the size of the population normalized to one, each individual’s share of profits is equal to \( \Pi \). To keep the analysis simple, we assume that profits remain untaxed. Let \( Y \) denote disposable income, i.e. \( Y = (1-t)l + \Pi \).

Individuals spend their income on consumption \( z \) of the traditional good and on a continuum of innovative goods. The innovative sector is populated by a continuum of monopolistic firms which are indexed by \( c \). The \( c \) corresponds to the innovation costs that arise in the development stage, which are distributed over the relevant interval with unit density and therefore provide a natural index. The innovative sector contains all firms with \( c \in \[0, c_H]\), and individuals buy a quantity \( x_c \) at a price \( p_c \) of each variety. Assuming linearly separable preferences, indirect utility \( U \) is given by

\[
U = \max_{z, x_c, c \in \[0, c_H]\}, l} \left\{ z + \int_{0}^{c_H} u(x_c) dc - e(l) \right\} \quad \text{s. t. } \quad z + \int_{0}^{c_H} p_c x_c dc \leq Y, (3.1)
\]

where \( e(l) \) is an increasing and convex function denoting disutility of working. The optimality condition \(-e'(l) + (1-t) = 0\) implicitly determines labor supply \( l(t) \) with \( l'(t) < 0 \). Demand for innovative goods follows from the optimality conditions \( u'(x_c) = p_c, c \in \[0, c_H]\). Choosing the specific functional form \( u(x_c) = A \frac{\eta}{1-\eta} x_c^{1-\frac{1}{\eta}}, \eta > 1 \), gives the downward sloping individual demand curves for the specific varieties of innovative goods:

\[
x_c = Ap_c^{\frac{1}{\eta}}, \quad c \in \[0, c_H]\). (3.2)
\]

Demand for specific brands is thus independent of an individual’s income and of the prices of other innovative product versions. The rest of the individual’s disposable income is spent on the traditional good.\(^4\)

\(^4\)The demand parameter \( A \) must be sufficiently small to ensure that individuals want to consume non-negative amounts \( z \) of the traditional good.
3.3.2. Innovative Firms

To enter the innovative sector, firms must engage in a costly development process. Once they have made the necessary investment, they are granted monopoly rights to their brands. When eventual production starts, innovation costs, which might include the fixed license fee in this scenario, are sunk and therefore do not influence the supply decision of firms. We assume that all firms have an identical production technology. They buy traditional goods as inputs and transform them into an equal quantity of their specific variety, without incurring additional costs. For each firm $c \in [0, c_H]$, gross profits are given by

$$\pi_c = p_c x_c - x_c. \quad (3.3)$$

With aggregate demand for each variety given by $x_c = A p_c^{-\eta}$ in (3.2) and a homogeneous production technology over all innovative firms, it is clear that all firms charge the same profit-maximizing price

$$p_c = p = \frac{\eta}{\eta - 1} \quad \forall c \in [0, c_H].$$

As $\eta > 1$, this price is higher than one, and firms in the innovative sector charge a mark-up over marginal costs of one. Maximum gross profits are then $\pi = \frac{px}{\eta} = A \left(\frac{\eta - 1}{\eta}\right)^{\eta - 1}$ for all innovative firms and are thus independent of $c$.

In the development stage, firms draw an idea for a particular product version from an exogenous pool. Each idea is associated with a value of necessary investment of $c \in [0, \bar{c}]$ units of the homogeneous good, and for each value $c$ there is exactly one product idea available. Once a respective idea is taken up by one firm, development and patenting occur instantaneously. This prevents other firms from working on the same idea, and the firm that drew idea with innovation cost $c$ is therefore indexed by $c$. If the necessary investment is exerted, the success of the innovation is certain.

With gross profits $\pi$ being the same across different product varieties, a firm with innovation cost $c$ will receive net profits of $\pi - c$ if it does all necessary development by itself. However, it has also the option to use the technology supplied by the research institute. Application of the technology reduces innovation costs proportionately by the term $\varphi(R)$, i.e. the firm ends up with effective innovation.

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5 We assume that the highest level of innovation costs $\bar{c}$ is so high that there will always be product ideas that are too costly to realize. Formally, this requires $\bar{c} > c_H$ in the respective scenarios, see below.
The size of the cost-reduction rises with the research input $R$ that is expended on the project by the research institute, $\varphi'(R) > 0$. When the institute owns the intellectual property to the technology, it charges firms a license fee $f$ in return for the right to use it, leaving the firm with net profits $\pi - \frac{\varphi(R)}{\varphi(R)} - f$.

As firms decide on entering the innovative sector and applying the cost-reducing technology, they compare net profits under the different options. Figure 3.1 shows net profits as a function of innovation costs $c$ for an arbitrary level of the license fee $f$. The firm with innovation cost $c_L^F$ is indifferent between using the technology or not because it has the same level of net profits under the two options. This threshold level is given by

$$c_L^F = \frac{\varphi(R)f}{\varphi(R) - 1}. \quad (3.4)$$

Firms with innovation cost $c < c_L^F$ have higher net profits if they do all development by themselves and thus they do not buy a license to the technology. Firms with innovation cost $c \geq c_L^F$ have higher net profits if they buy a license. However, firms only enter the innovative sector as long as their net profits are non-negative. The last firm entering is therefore given by

$$c_H^F = \varphi(R)(\pi - f). \quad (3.5)$$

This threshold then also determines the size of the innovative sector and the mass of different brands that will be supplied in the market.

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6Note that the superscript $F$ indicates the licensing scenario with fixed fees.
Note that if research results are not the property of the research institute and it is therefore unable to charge a fee (this scenario is indicated by the superscript $N$), all firms that enter the innovative sector will use the technology, implying $c_L^N = 0$. The size of the sector is then given by $c_H^N = \phi(R)\pi$. For a given level of $R$, a wider range of brands are available when licensing is prohibited.

### 3.3.3. Research Institute

In the literature on public higher education and research institutions, it is generally assumed that such an institution’s goal is to maximize the prestige associated with the teaching and research it undertakes (cf. Dasgupta and David, 1994; Stephan, 1996). Indicators of prestige comprise skill levels or professional success of graduates, scientific publications, prizes, awards etc., and are traditionally a combination of quantitative and qualitative measures. One point of concern that is often brought forward in the discussion of licensing activities is that they distort researchers’ efforts away from teaching and basic research and lead to a deterioration in their quality. However, theoretical studies predict that although researchers are likely to increase their share of applied work, this comes at the cost of diminished leisure time rather than a cut-back on basic research and teaching (cf. Jensen and Thursby, 2004; Thursby, Thursby, and Gupta-Mukherjee, 2007). These predictions are also supported by empirical evidence, e.g. Azoulay, Ding, and Stuart (2006, 2007) and Thursby and Thursby (2007b) (see also the discussion in Thursby and Thursby, 2007a).

We therefore consider only one activity of the research institute in our model, i.e. the performance of research in a particular field, and assume that the institute’s objective function depends only on this activity. We do not explicitly state whether this is a more basic or a more applied project, but take its applicability as given. In this situation, prestige essentially depends on the size of a project and on publications associated with it. Both of these measures depend non-negatively on the resources that are devoted to the project. We thus assume that the institute’s prestige $\Omega(R)$ is an increasing function of research inputs $R$.

This assumption also implies that the research institute will be interested in generating licensing revenues that it can again spend on the current project. This

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7Note that we do not take into account the risk that might be associated with a single research project. We assume rather that what we call a ‘project’ is in fact a bundle of smaller, well-diversified projects in a particular field of research, so that the resulting technology is a continuous and differentiable function of research inputs.
implication is also in line with empirical evidence. Jensen and Thursby (2001) present results of an investigation of the objectives of technology transfer officers, researchers and administrators working at U.S. universities engaged in licensing activities. For 70% of technology transfer officers and administrators, generating revenues was extremely important. Among researchers, only 40% expressed this view, but almost 80% of them judged the attraction of sponsored research an extremely important outcome of technology transfer. In this sense, we also assume that the generated license revenues are again dedicated to the current research project. This increases the amount of project work done (for a given state subsidy), but does not come at the cost of channeling resources away from other activities. Our model thus replicates the behavior of researchers found in the micro models of Jensen and Thursby (2004) and Thursby, Thursby, and Gupta-Mukherjee (2007), which themselves are supported by empirical evidence (see above).

When the institute undertakes its research project, it transforms research inputs $R$ into research results, leading to a technology $\varphi(R)$ and to prestige $\Omega(R)$. Research inputs consist only of traditional goods, which the institute must purchase at the market price. When patenting and licensing of public research is allowed, the institute’s revenues come from two sources. First, it receives a lump-sum subsidy $G$ from the government and, secondly, it generates revenues $L$ by selling licenses to its technology. In this case of a uniform fee for all licensee firms, total revenues amount to $L^F = f(c^F_H - c^F_L)$. Being a prestige maximizer, the institute spends its total disposable income on research inputs, thus its budget constraint is given by $G + f(c^F_H - c^F_L) - R = 0$. The institute has two instruments to maximize prestige: $R$, the quantity of research inputs, and $f$, the fee it charges licensee firms. Its optimization problem is thus

$$\max_{R,f,\mu} \Omega(R) + \mu \left[ G + f(c^F_H - c^F_L) - R \right],$$

where $\mu$ denotes the Lagrange multiplier associated with the budget constraint. The optimality conditions for $R$, $f$ and $\mu$ are

$$R : \quad \Omega'(R^F) + \mu \left[ f \left( \frac{dc^F_H}{dR} - \frac{dc^F_L}{dR} \right) - 1 \right] = 0,$$

$$f : \quad \mu \left[ (c^F_H - c^F_L) + f \left( \frac{dc^F_H}{df} - \frac{dc^F_L}{df} \right) \right] = 0,$$

$$\mu : \quad G + f(c^F_H - c^F_L) - R^F = 0.$$
The expression in brackets in the second equation has to equal zero. This condition leads to maximum licensing revenues for the institute. On the one hand, an increase in the license fee $f$ leads to higher payments by all firms in $[c_{FH}^F, c_{FL}^F]$, which is captured in the first term. On the other hand, the price increase leads to a change in the number of licenses demanded, expressed in the second term. As $\frac{dc_i^F}{df}$ is negative and $\frac{dc_f^F}{df}$ positive, this change is unambiguously negative. Using (3.4) and (3.5) gives the optimal license fee $f$ as a function of optimal research input $R^F$, which itself depends on license revenues:

$$f = \pi \frac{\varphi(R^F) - 1}{2\varphi(R^F)}. \quad (3.6)$$

The institute thus charges a higher fee the higher the gross profits $\pi$ of firms producing innovative goods, and the more effective its technology is in reducing innovation costs. Inserting this expression into the institute’s budget constraint, the optimal value for research input $R^F$ is determined by the equation

$$G + (\varphi(R^F) - 1)\frac{\pi^2}{4} - R^F = 0. \quad (3.7)$$

Generally, the left hand side is a concave function in $R$, and for $R = 0$, its value is $G$ and thus non-negative. It follows that there is only one positive value $R^F$ that satisfies equation (3.7). Optimal research input is bigger the higher the transfer $G$ and firms’ gross profit $\pi$. In contrast, when the institute does not own the intellectual property of its research results and is therefore prohibited from charging license fees, it can only spend the government transfer on research inputs: $R^N = G$.

By inserting the solution for the license fee from (3.6) into (3.4) and (3.5), we can now further specify the levels of innovation costs that separate the different groups of innovating firms. The threshold separating autonomously innovating firms from those buying a license is $c_{FL}^F = \frac{\pi}{2}$. Thus, the value of innovation costs for which the payment of the license fee exactly offsets the reduction in innovation costs is strictly positive and independent of the institute’s research activities. The size of the innovative sector in this scenario is $c_{FH}^F = \frac{\pi}{2}(\varphi(R^F) + 1)$ and depends positively on $R^F$.

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8The condition with respect to $R$ combined with the solution for $f$ in (3.6) and $1 - \frac{\varphi(R^F)}{4}\pi^2 > 0$ imply $\mu > 0$. Note that the term $1 - \frac{\varphi(R^F)}{4}\pi^2$ is the negative of the slope of the function implied by the left-hand side of equation (3.7) at $R$. As the function gives a positive value at $R = 0$ and is concave, it can only cross the $R$-axis at some point $R^F > 0$ coming from above. Thus, the slope must be negative at this point and $1 - \frac{\varphi(R^F)}{4}\pi^2 > 0$ holds.
3.3.4. Public Research Subsidization

The government subsidizes the institute’s research activities. The necessary funds must be raised by the tax on labor income. So the government seeks the combination of tax rate \( t \) and transfer \( G \) that satisfies its budget constraint

\[
 tl(t) - G \geq 0 \quad (3.8)
\]

and at the same time maximizes individuals’ indirect utility (3.1). In order to determine indirect utility, we first calculate aggregate disposable income explicitly. As shown in Section 3.3.1, individuals earn a net labor income of \((1 - t)l(t)\). They are also the owners of all firms in the economy and receive aggregate profits \( \Pi \). With perfect competition, profits in the traditional sector are driven down to zero. However, in the innovative sector, firms earn monopoly profits on their particular product variety. Net profits are then transferred to the households. Aggregate disposable income is thus

\[
 Y^i = (1 - t)l(t) + c^i_{H}(R^i)\pi - C^i(R^i)
\]

with \( C^i = \int_{0}^{c^i_{H}(R^i)} \frac{c}{\varphi(R^i)} dc \) if \( i = N \),

\[
 C^i = \int_{0}^{c^i_{L}} c dc + \int_{c^i_{L}}^{c^i_{H}(R^i)} \left( \frac{c}{\varphi(R^i)} + f(R^i) \right) dc \quad \text{if } i = F,
\]

where \( C^i \) denotes aggregate innovation costs of firms in the different scenarios. Solving the budget constraint for expenditures \( z \) on the traditional good and substituting the corresponding expression into the utility function in (3.1) gives the following expression for indirect utility

\[
 U^i = Y^i(R^i) + c^i_{H}(R^i) \cdot CS - e(l(t)),
\]

\[
 CS \equiv u(x) - px = \pi \frac{\eta}{\eta - 1}.
\]

The second term on the right captures the consumer surplus out of consumption of \( c^i_{H} \) varieties of differentiated goods, i.e. consumption utility minus the amount of the traditional good that must be foregone in payment for the differentiated goods. As \( \eta > 1 \), this expression is always positive at optimal consumption levels.

At this stage, indirect utility is a function of the government’s decision variables \( G \) and \( t \) only, i.e. \( U^i(t, G) \). From the convexity of the disutility of working function, it
follows immediately that indirect utility is decreasing and convex in \( t \). Further, we know that \( R^N \) is linear and \( R^F \) is locally increasing and concave in \( G \), implying that indirect utility is increasing and concave in \( G \) in both scenarios. The government will therefore choose the lowest possible tax rate to fund a given research subsidy, and its budget constraint in (3.8) will be binding. The government solves the following social welfare maximization problem:

\[
\max_{t, G} \ U^i(t, G) + \lambda [tl(t) - G], \quad i = N, F,
\]

where \( \lambda \) is the Lagrange multiplier associated with the government’s budget constraint. To be able to compare optimal public research funding in the two scenarios of no-licensing and licensing by fixed fee, we derive the optimality conditions separately for the two cases.

**Optimal Research Subsidy without Licensing**

When the research institute cannot patent its research results, the optimal research subsidy is determined by the condition

\[
\int_0^{R^N} c\phi'(R^N) \frac{dR^N}{dG} dc + \frac{dc^N}{dR^N} \frac{dR^N}{dG} CS = \lambda^N.
\]

The left hand side captures the marginal benefits of an increase in the subsidy \( G \). First of all, a rise in the subsidy increases research inputs one-to-one: \( \frac{dR^N}{dG} = 1 \). The technology thus becomes more effective and innovation costs of all firms in the innovative sector are reduced. Individuals therefore receive higher net profits, as captured in the first term. Secondly, higher net profits attract more firms into the innovative sector, and the ensuing gain in product variety increases consumer surplus. Optimally, these marginal benefits are just offset by the marginal cost of public funds \( \lambda^N \) that are necessary to finance the subsidy. These can be derived from the optimality condition for \( t \):

\[
-l(t) + \lambda [l(t) + tl'(t)] = 0 \quad \rightarrow \quad \lambda^N = \frac{1}{1 - \frac{R^N}{1-R^N}},
\]

\[
(3.10)
\]

\footnote{Indeed, differentiating (3.7) yields \( \frac{dR^F}{dG} = \frac{1}{1 - \psi(R^F)} \phi''(R^F) \frac{dR^N}{dG} \), which is positive according to Footnote 8. The second order differential is \( \frac{d^2R^F}{dG^2} = \frac{1}{(1 - \psi(R^F))^2} \phi'''(R^F) \frac{dR^N}{dG} \). In this expression, the first factor is again positive, whereas the second factor is negative, given the standard assumption \( \phi''(R) < 0 \), implying that the optimal \( R^F \) is locally increasing and concave in \( G \).}
where \( t^N \) finally follows from the binding budget constraint and \( \varepsilon \) is the elasticity of labor supply with respect to the tax rate. The workers’ reduction of labor supply as a response to an increase in the tax rate thus raises the marginal costs of public funds above unity.

We show in Appendix 3.B that the research subsidy implied by conditions (3.9) and (3.10) is lower than the social planner’s choice in a second-best equilibrium.

**Optimal Research Subsidy with Licensing**

When the research institute can patent and license its technology to firms, the resulting excludability of the technology alters the government’s rationale for research subsidization. The optimal subsidy \( G \) must now satisfy the condition

\[
\int_{c_L}^{c_H} \left( \frac{c \phi'(R^F) dR^F}{\phi(R^F)^2} - \frac{df}{dR^F} \right) dc + \frac{dc_H}{dR^F} \frac{dR^F}{dG} CS = \lambda^F, \tag{3.11}
\]

where the marginal cost of public funds is given by \( \lambda^F = \frac{1}{1 - \frac{1}{1 - \tau^F} \varepsilon} \). The left-hand side again shows the marginal benefits of an increase in \( G \). A higher transfer to the research institute increases research activity by \( \frac{dR^F}{dG} = \frac{1}{1 - q'(R^F) \frac{d\pi}{dR^F}} \), which is greater than one. The higher subsidy raises the effectiveness of the cost-reducing technology and thereby increases license revenues. From the financial perspective, licensing thus provides a leverage on the public subsidy.

As the technology is now excludable, only firms that actually buy a license, i.e. firms with \( c \in [c_L, c_H] \), can profit from the increased effectiveness of the technology through decreased innovation costs. However, the research institute now also charges a higher license fee, as \( \frac{df}{dR^F} > 0 \) by (3.6). Inserting for \( f, c_L, c_H \) from (3.6), (3.4) and (3.5) and solving the integral shows that the total change in net innovation costs remains negative, and thus households receive higher net profits. Additionally, higher net profits again induce more firms to enter the innovative sector, which increases product variety and consumer surplus. However, for a given level of \( R \), the increase in innovative firms is now smaller than when licensing is prohibited, as \( \frac{df}{dR} = \pi q'(R) < \frac{dc_H}{dR} = \pi \phi'(R) \). At the optimal subsidy level, the marginal benefits are offset by the marginal cost of generating the corresponding public funds by the labor income tax.

Appendix 3.B shows that also when patenting and licensing are possible, the level of research inputs that is implied by (3.11) is lower than the research inputs that would be chosen by the social planner.
3.3.5. Comparison of Research Activities

A comparison of the optimality conditions (3.9) and (3.11) shows that the excludability of the technology under licensing, the direct fee costs and the indirect effect of fee costs on the market entry decision of firms are the three arguments for a reduction of the public research subsidy compared to the case without licensing, as they reduce the marginal benefits that are associated with its payment. In contrast, as licensing revenues provide a leverage on the government transfer and thus further stimulate research activity, they provide an argument for an increase in the transfer G. Which one of these effects dominates is not clear a priori. In the next step, we analyze how optimal levels of research activity differ under the two scenarios, and then derive the implications for the optimal transfer levels.

To assess the change in the optimal level of research inputs, we evaluate the derivative of the social welfare function with respect to G in the licensing case at the optimal level of research inputs $R^N$ from the case where licensing is prohibited. If the derivative is positive, it is optimal to further increase the public subsidy, thus total research inputs will be higher in the licensing case. After inserting for the specific values for $c_L^L$, $c_H^L$ etc. (see equations (3A.4) and (3A.6) in Appendix 3.B), we arrive at the following condition for a rise in research activity that must hold at the optimal level $R^N$:

$$\frac{1}{2} + \frac{\eta}{\eta - 1} < \frac{\lambda^N}{\lambda^F} \left(1 + \frac{\eta}{2(\eta - 1)}\right) + \frac{\lambda^N}{4}.$$  \hspace{1cm} (3.12)

Note that for a given level of research inputs $R$, the tax rate on labor income associated with the necessary raising of government revenues is smaller when licensing is possible than when not, as the research institute then also has license revenues as a source of funding $R$. This implies that the marginal cost of public funds caused by a given level of research funding is smaller when licensing is possible: $\lambda^N > \lambda^F$ for a given $R$.

An inspection of condition (3.12) shows that in general, a rise in research activity is more likely to take place the higher $\lambda^N$. If the financing cost of the public subsidy is very high when licensing is prohibited, the new source of revenues for the research institute and the associated reduction in necessary public funding have a strong positive effect on welfare, thus allowing for a rise in total research inputs.

On the other hand, the higher $\frac{\eta}{\eta - 1}$, the more likely it is that optimal research inputs fall when licensing is possible (unless $\lambda^N/\lambda^F \geq 2$, which, however, is very
unrealistic). The term $\frac{\eta}{\eta-1}$ determines the increase in consumer surplus that is associated with the rise in the range of innovative goods (remember that consumer surplus per variety is $CS = \pi \frac{\eta}{\eta-1}$). As mentioned above, as $\frac{dc^N}{dR} = \pi \varphi'(R) > \frac{dc^f}{dR} = \frac{3}{2}\varphi'(R)$ for a given level of $R$, the increase in the range of available products is smaller in the licensing case than without licensing. So the higher the increase in consumer surplus that is foregone in this way, the lower is the public research funding the government will find optimal, and the less likely is an increase in the level of research.

In an attempt to gauge the quantitative dimension of the terms captured in condition (3.12), we note first that the discrepancy between the government transfers flowing to the research institute in the two scenarios is not likely to be very large, so the marginal cost of public funds will be very similar: $\frac{\lambda^N(R^N)}{\lambda^f(R^N)} \approx 1$. Condition (3.12) then simplifies to

$$\frac{3}{2} + 2 \frac{\eta}{\eta-1} < \lambda^N.$$

As the absolute value of the price elasticity of demand $\eta$ is restricted to be higher than 1, the marginal cost of public funds would at least have to surpass 3.5 (for $\eta \to \infty$) to make it possible for this condition to hold. As estimates of $\lambda$ mostly lie in the range of 1 - 2 (cf. Kleven and Kreiner, 2006), it must be assumed that this inequality does not hold in most cases. This implies that with optimal adjustment of the public subsidy, total resources available to the institute for doing research must be expected to fall in this framework when licensing is possible.

The fact that research activities and thus the institute’s prestige can deteriorate after the policy reform demonstrates a commitment problem of the institute. In this case, the research organization would actually prefer the situation of the policy regime in which it cannot charge license fees. However, it cannot credibly announce to the government that it will not request any fees when it is permitted to do so. At the time the institute decides on charging a license fee, it has already received the government’s transfer, and therefore will always use the opportunity to generate additional revenues via the licensing of its technology. This, of course, is anticipated by the government, which reduces its transfer accordingly.

The result that research inputs will fall implies that the government reduces its research subsidy when licensing is possible. The negative effects of excludability and fees thus dominate the positive effect of higher research activity for a given government subsidy. Consequently, overall innovative activity by firms and thus the range of goods provided in the innovative sector will fall with licensing.
3.4. Alternative Fees

Optimality condition (3.11) makes clear that the optimal research subsidy in the case of licensing depends on the structure of the license fee and how it affects innovation and market entry decisions of firms. It is therefore important to consider also other forms of license fees that are often used in practice and analyze how the government’s decision criterion changes with the different forms. Apart from fixed fees per firm, the most common compensation methods stipulated in licensing contracts are equity shares of licensee firms and royalty payments per unit of output (cf. Jensen and Thursby, 2001). Both of these categories might also be combined with fixed fees. However, to highlight the differences in the optimal research subsidization policy, we concentrate on licensing by equity shares and licensing by royalties only.

3.4.1. Equity Shares

Under licensing by equity shares, the research institute receives a stake $s$ in the innovative firms that buy a license. In this case, a firm with innovation cost $c$ ends up with net profits of $(1-s)(\pi_c - \frac{c}{\varphi(R)})$ if it buys access to the technology, instead of $\pi_c - c$ when not buying a license. It is obvious that this compensation scheme does not affect the firms’ behavior once they have made it to the production stage: they still charge the same price $p_c = p = \frac{\eta}{\eta-1}$ for each variety and receive equal gross profits of $\pi_c = \pi$ $\forall c \in [0, c^S_H]$ as given in Section 3.3.2.\textsuperscript{10} The firm with the lowest innovation cost for which it is profitable to buy a license is given by

$$c^S_L = \pi \frac{s \varphi(R)}{\varphi(R) - 1 + s}, \quad (3.13)$$

which is increasing in the equity share $s$ the institute receives as payment and decreasing in $R$. The last firm that enters the innovative sector in this scenario has development cost

$$c^S_H = \pi \varphi(R).$$

For a given level of research activity $R$, the number of innovative firms and the range of different products is thus the same under licensing by equity as when licensing is prohibited. As the last firm in the sector has zero net profits, it pays

\textsuperscript{10}The superscript $S$ denotes the scenario of licensing by equity shares.
nothing for the use of the technology. Its innovation decision is not distorted compared to the case when the technology is a public good.

Aggregate license revenues now amount to \( L^S = \int_{c_L}^{C_S} s \cdot \left( \pi - \frac{c}{\varphi(R^S)} \right) dc \). The institute maximizes prestige and license revenues by demanding an equity share of

\[
s = \varphi(R^S) - 1
\]

(3.14)

from licensee firms, where the optimal research input \( R^S \) is determined by the institute’s budget constraint \( G + L^S - R^S = 0 \). Inserting this solution into (3.13) yields \( c_L^S = \pi \frac{\varphi(R^S)}{2} \), so exactly one half of innovative firms develop their products autonomously, while the other half buy access to the cost reducing technology.

Households now receive only a share \( 1 - s \) of licensee firms’ net profits and their aggregate disposable income is given by

\[
Y^S = (1 - t)l(t) + \int_0^{c_L^S} (\pi - c)dc + \int_{c_L^S}^{C_S} (1 - s) \left( \pi - \frac{c}{\varphi(R^S)} \right) dc.
\]

(3.15)

Note that as prices and consumed quantities of innovative goods are the same as in the scenarios analyzed in Section 3.3, consumer surplus per variety is again given by \( CS = \pi \frac{\eta}{\eta - 1} \). The government maximizes social welfare by choosing the research subsidy \( G \) and the tax rate \( t \) that jointly satisfy its budget constraint and maximize indirect utility (3.1) of individuals: \( \max_{t,G} U^S(t, G) + \lambda [tl(t) - G] \). The optimal research subsidy is determined by the condition

\[
\int_{c_L^S}^{C_S} \left[ (1 - s) \frac{c}{\varphi(R^S)} \frac{\varphi'(R^S)}{[\varphi(R^S)]^2} - \frac{ds}{dR^S} \left( \pi - \frac{c}{\varphi(R^S)} \right) \right] dR^S dc + \frac{dc^S}{dR^S} \frac{dR^S}{dG} - \frac{dc^S}{dG} \frac{dR^S}{dG} CS = \lambda^S,
\]

(3.16)

where \( \lambda^S = \frac{1}{1 - \frac{t^S}{1 - t^S}} \) is the marginal cost of public funds at the optimal tax level \( t^S \) in this scenario. Note that by differentiating the research institute’s budget level \( R^S = G + \varphi(R^S)(\varphi(R^S) - 1) \frac{\pi}{8} \), we know that an increase in the subsidy \( G \) increases total research inputs by \( \frac{dR^S}{dG} = \frac{1}{1 - \frac{t^S}{1 - t^S} (2\varphi(R^S) - 1) \varphi'(R^S)} \).

Marginal benefits of an increase in \( G \) again comprise the increase in net profits that are shifted to households, as licensee firms’ innovation costs are reduced more effectively. However, they also have to pay a higher equity share to the research institute, which diminishes the increase in individuals’ net gain. Further, there is

\[11\text{Note that } \varphi(R) \text{ cannot exceed } 2 \text{ in this scenario.}\]
a gain in consumer surplus as entering the innovative sector becomes profitable for more firms.

Compared to the optimality condition (3.9) when licensing is prohibited, the excludability of the technology and the direct fee costs again call for a reduction in the transfer $G$, while the institute’s possibility to pursue additional research because of license revenues, and thus $\frac{dR^S}{dG} > 1$, is an argument in favor of a higher transfer. However, there is now no further distortion of the expansion of the innovative sector because of the license payment as it happens in the scenario with fixed fees per firm.

### 3.4.1.1. Research under Licensing by Equity Shares vs. No-Licensing

We can now analyze whether it is likely that the institute’s total research activity increases when we move from the no-licensing situation to the regime of licensing by equity shares. We therefore evaluate the derivative of social welfare with respect to the government subsidy $G$ in this scenario at the optimal value of research inputs $R^N$, i.e. where the optimality condition (3.9) holds. After inserting for the specific values of $c^i_H$, $c^i_L$ etc. (see equations (3A.4) and (3A.9) in Appendix 3.B), condition $R^S > R^N$ is fulfilled if and only if

$$\frac{1}{2} + \frac{\eta}{\eta - 1} < \frac{\lambda^N}{\lambda^S} \left( \frac{3}{4} + \frac{\eta}{\eta - 1} - \frac{\varphi(R^N)}{2} \right) + \frac{\lambda^N}{4} \left( \frac{\varphi(R^N)}{4} - \frac{1}{8} \right).$$

Note again that the marginal cost of public funds for a given level of research inputs must be lower in the equity scenario than when licensing is prohibited (so $\frac{\lambda^N}{\lambda^S} > 1$), as the additional source of financing research inputs means that only a part of these expenditures must be paid for by the public subsidy. As in the case of fixed fees, research activities are more likely to increase under licensing by equity the higher the marginal cost of public funds in the no-licensing case. However, a higher consumer surplus from innovative goods, captured in the term $\frac{\eta}{\eta - 1}$, now also helps to increase $R^S$ over $R^N$. This is due to the fact that market entry of innovative firms is not influenced by the payment of the equity share at the margin. As for a given increase in the public subsidy the ensuing rise in research activity is higher under licensing, the range of brands and thus consumer surplus increase more strongly.

Again noting that, in practice, the marginal cost of public funds is very similar in
the two scenarios, $\lambda^N/\lambda^S \approx 1$, the condition simplifies to

$$\lambda^N > 2.$$ 

Given the estimates of Kleven and Kreiner (2006) for marginal costs of public funds in the case of endogenous intensive labor supply, it is not impossible that this threshold is surpassed and total research funding expands with licensing via equity. Such an increase might even be financed with a lower tax rate than in the no-licensing regime, as the revenues from equity shares provide an additional source of funding research activities.

### 3.4.1.2. Research under Licensing by Equity Shares vs. Fixed Fees

Another interesting question is which of the two licensing scenarios we have analyzed so far will be preferred by the research institute. To address this issue, we must distinguish two situations: first, the research institute can itself decide on the license form, and does so only after it has received the government transfer. The second possibility is that the license form is determined before the subsidy has been paid out, and access to the subsidy is conditional on applying the respective license form afterwards.

Suppose we are in the first situation. Given a subsidy $G$ that the institute receives from the government, it can obtain a level of research activity $R^F$, determined by the budget constraint $G + (\varphi(R^F) - 1)\pi^2 - R^F = 0$, if it charges optimal fixed fees (see equations (3.6) and (3.7)). When opting for equity shares, the institute reaches an optimal research level $R^S$ determined by $G + \varphi(R^S)(\varphi(R^S) - 1)\pi^2 - R^S = 0$ (see Section 3.4.1). Remembering that in the equity scenario, an interior solution for optimal equity shares requires that $\varphi(R^S) < 2$ (see equation (3.14)), the comparison of the two budget constraints implies that the research level under licensing by fixed fees will be higher than under licensing by equity shares. The prestige-maximizing institute thus chooses to charge licensee firms fixed fees. As the government anticipates this outcome, it will subsidize research by an amount $G$ that satisfies optimality condition (3.11).

The question remains whether this really leads to the best situation from the research institute’s point of view. It is conceivable that by tying the license form of equity shares to the research subsidy, the institute will eventually attain a higher level of research activities and prestige. As we have seen in Section 3.4.1 above, the
fact that firms’ market entry decision is not distorted by license payments in the form equity shares certainly provides an argument in favor of this license form.

To analyze this question thoroughly, we compare the optimality conditions for public transfers in the scenarios of licensing by fixed fees (equation (3.11)) and licensing by equity (equation (3.16)). In particular, we evaluate the derivative of the social welfare function in the case of licensing by equity at the optimal value of research \( R^F \) following from the scenario postulating fixed fees. If the derivative is positive, further research subsidization is called for, and \( R^S \) will be higher than \( R^F \).

Using the specific forms (3A.6) and (3A.9) of the optimality conditions, \( R^S > R^F \) holds if and only if

\[
\frac{3}{4} - \frac{\varphi(R^F)}{2} + \frac{\eta}{\eta - 1} + \frac{2\varphi(R^F) - 3}{8} \lambda^S > \frac{\lambda^S}{\lambda^F} \left( \frac{1}{8} + \frac{\eta}{2(\eta - 1)} \right). 
\]

From the discussion above it follows that as long as \( \varphi(R) < 2 \), license revenues generated by fixed fees are higher than those generated by equity shares, for a given \( G \). A given level of research inputs \( R^F \) can thus be obtained by a lower tax rate in the case of fixed fees, implying \( \frac{\lambda^S(R^F)}{\lambda^F(R^F)} > 1 \). The condition nicely illustrates the differential impact of fees on the market entry decision of firms and thus on optimal research subsidization. With fixed fees, the additional consumer surplus from the marginal firm is captured by \( \frac{\eta}{2(\eta - 1)} \), whereas with equity shares, the corresponding term is \( \frac{\eta}{\eta - 1} \). Thus, the higher the consumer surplus from an additional variety of the innovative good, the more likely is it that licensing by equity shares leads to higher research activity (unless \( \lambda^S/\lambda^F > 2 \), which is very unlikely, however).

To get a better impression of the likelihood with which the condition for \( R^S > R^F \) holds, we again recognize that in practice the marginal cost of public funds will be very similar in the two cases, so assume \( \lambda^S(R^F)/\lambda^F(R^F) \approx 1 \). The condition then simplifies to

\[
\frac{5}{8} - \frac{\varphi(R^F)}{2} + \frac{\eta}{2(\eta - 1)} + \frac{2\varphi(R^F) - 3}{8} \lambda^S > 0.
\]

Considering only interior solutions in the equity case, we impose that \( \varphi(R^F) < 2 \). Further, the smallest value that \( \frac{\eta}{\eta - 1} \) can take is 1 when \( \eta \to \infty \). Thus, the first three terms taken together are always positive. Inspecting the last term makes clear that if \( \varphi(R^F) > \frac{3}{2} \), research activity under licensing by equity is strictly higher than licensing under fixed fees when subsidy payment can be conditioned on the specific license form. If \( \varphi(R^F) < \frac{3}{2} \), the strictest condition for the inequality to hold
is given when \( \varphi(R^f) = 1 \). In this case, only if \( \lambda^S > 5 \), licensing by fixed fees leads
to higher research activity than licensing by equity shares. Given the estimates for
marginal costs of public funds found in Kleven and Kreiner (2006), it is unlikely
that this condition is fulfilled. For higher values of \( \varphi(R^f) \), the threshold that \( \lambda^S \)
has to surpass is even higher. Thus, even the most conservative parameterization
implies that licensing by equity normally results in higher overall research activity
than licensing by fixed fees. As for a given transfer \( G \), optimal license revenues
are lower in the equity scenario than in the fixed fee case, it also follows that a
higher public research subsidy is paid out under licensing by equity shares.

This section makes clear that when licensing of publicly subsidized research is
possible, it can be beneficial for the research institute that subsidy payments are
conditional on the use of a specific license form. When both instruments of fixed
fees and equity shares are available and the institute can freely choose a license
form after it has received a transfer, it will charge licensee firms a fixed fee (as
long as \( \varphi(R) < 2 \)). Anticipating this situation, the government chooses the transfer
level that maximizes social welfare under fixed fees. However, when allowing the
government to tie a specific license form to its subsidy, the postulation of equity
shares would lead to a higher transfer and higher research activity for the institute.

3.4.2. Royalty Payments

In this section, we briefly analyze the third form of license payments often stipu-
lated in licensing contracts, which are royalties per unit of output. Denoting the
royalty rate by \( r \), an innovative firm’s production problem is in this case

\[
\max_p x(p)p - (1 + r)x(p) \quad \text{with } x(p) = Ap^{\eta-1}\text{ as in (3.2)}.
\]

The optimal price is then set to \( p^R = \frac{\eta}{\eta-1}(1 + r) \) and increases with the royalty
rate \( r \).\(^{12}\) In contrast to the situations analyzed before, the prices and consumed
quantities \( x^R(r) \) of innovative goods supplied by licensee firms are now influenced
by license payments. These firms’ gross profits, albeit net of royalties, then amount
to \( \pi^R = \pi(1 + r)^{1-\eta} \).

When deciding on whether to buy a license, the firm with innovation cost \( c \)
compares net profits under the two options: \( \pi - c \) versus \( \pi^R - \frac{c}{\varphi(R)} \). The firm that

\(^{12}\)The superscript \( R \) indicates the scenario of licensing by royalties.
is indifferent between the two options is determined by the innovation cost

\[ c_R^L = \pi [1 - (1 + r)^{1-\eta}] \frac{\varphi(R)}{\varphi(R) - 1}, \]

which increases in \( r \). The number of different varieties that are sold in the innovative sector is determined by the innovation cost of the firm generating just zero net profits, i.e.

\[ c_R^H = \pi(1 + r)^{1-\eta} \varphi(R). \]

Market entry is thus also negatively influenced by the royalty rate (as \( \eta > 1 \)). Aggregate license revenues flowing to the research institute amount to

\[ L^R_R = r x_R^R (c_R^H - c_R^L). \]

The research organization maximizes prestige and license income by choosing the royalty rate that fulfills the condition

\[ \frac{1 - r(\eta - 1)}{1 - 2r(\eta - 1)} (1 + r)^{\eta - 1} = \varphi(R^R), \] (3.17)

where optimal research inputs \( R^R \) are determined by the budget constraint \( G + L^R - R^R = 0 \). The optimality condition cannot be solved explicitly for \( r \). It is clear, however, that the left-hand side increases with \( r \), so the optimal royalty rate is increasing in the research activity of the institute: \( \frac{dr}{dR} > 0 \).

Individuals’ indirect utility is now given by

\[ U^R = Y^R + \int_0^{c_R^L} CS dc + \int_{c_R^L}^{c_R^H} CS^R dc - e(l(t)) \]

with \( Y^R = (1 - t) l(t) + \int_0^{c_R^L} (\pi - c) dc + \int_{c_R^L}^{c_R^H} \left( \frac{\pi R - \frac{c}{\varphi(R^R)}}{\varphi'(R^R)} \right) dc. \]

In contrast to the situations analyzed before, consumer surplus \( CS^R = u(x^R) - p^R x^R \) from goods supplied by licensee firms is now negatively affected by the royalty rate: \( \frac{dCS^R}{dr^R} = -x^R \frac{dp^R}{dr^R} = -x^R \frac{R}{\eta - 1} \). In order to maximize social welfare, the government subsidizes the institute’s research by an amount \( G \) that satisfies equation

\[
\int_{c_R^L}^{c_R^H} \left( \frac{c \varphi'(R^R)}{[\varphi(R^R)]^2} + \frac{d\pi^R}{dR^R} \right) dR^R \frac{dG}{dR^R} dc + \frac{dc_R^H}{dR^R} \frac{dG}{dR^R} CS^R \]

\[ + \frac{dc_R^L}{dR^R} \frac{dR^R}{dG} [CS - CS^R] - (c_R^H - c_R^L)x^R \frac{dp^R}{dR^R} \frac{dR^R}{dG} = \lambda^R. \] (3.18)

Compared to the situation when the research institute does not hold the intellectual
property on its research output (equation (3.9)), the additional research that can be performed due to the revenues from royalties, \( \frac{dR}{dG} > 1 \), again is an argument for a relatively higher transfer. Against this stand four arguments that imply a lower research subsidy under licensing by royalties. The first is the excludability of the technology that implies that only firms that buy a license can realize a reduction in their innovation costs. The second are the direct fee costs that reduce profits flowing to individuals. The third argument is the distortion of firms’ market entry decision, leading to lower market entry resulting from an increase in research inputs: \( \frac{dc^N}{dR} < \frac{dc^R}{dR} \) for a given level of \( R \). Qualitatively, these three effects also occur under licensing by fixed fees. The fourth argument, however, only applies to licensing by royalties: charging a royalty rate reduces consumed quantities and increases the price of innovative goods. This reduces the consumer surplus from those varieties produced by licensee firms, \( CS^R < CS \). An expansion of the range of brands thus has only a smaller positive effect on aggregate consumer surplus. In addition, as a rise in \( G \) leads to a higher royalty rate and higher prices, consumer surplus from goods produced by licensee firms is further distorted. Compared to the situation of fixed fees, also firm profits net of license payments are negatively affected by royalties.

As we cannot explicitly solve condition (3.17) for the optimal royalty rate, it is not possible to make more direct comparisons of the optimality conditions for research subsidies under the different scenarios. However, due to the additional distortions that arise under licensing by royalties, it seems very unlikely that optimal research funding will increase in this scenario relative to the no-licensing equilibrium.

### 3.5. Conclusion

As a reaction to the growing importance of university research for industrial innovation, many countries have recently introduced reforms regarding the assignment of intellectual property rights on publicly subsidized research. In most cases, these property rights are granted directly to the research performing institutions. This enables them to license their research results to interested firms and thus generate additional resources for pursuing their projects.

However, as patenting and licensing strongly alters the nature of research organizations’ technologies, the rationale for public research subsidization must be reconsidered. The present paper therefore examines the implications of a change
in intellectual property policy on the government’s rationale to subsidize research in a general equilibrium framework. The most commonly mentioned objection to licensing, i.e. that dissemination of technologies which are helping private innovation is curtailed to firms that buy a license, indeed calls for a relative decrease in the public subsidy. When license payments take the form of uniform fees or royalties, this negative influence is even aggravated by the fact that the additional license costs reduce market entry by innovative firms. This effect is not present when firms exchange a share of their equity for the right to use a technology.

The analysis shows that unless the marginal cost of public funds are very high when licensing is not possible, a switch in intellectual property policy is likely to call for such a strong reduction in the public subsidy that overall research activity, including the part funded by license revenues, will fall. Further, the comparison of licensing by equity shares and licensing by fixed fees implies that it can be beneficial for the research organization to make subsidy payments conditional on the application of specific license forms. These implications should be kept in mind in the design of intellectual property policy.
Appendix

3.A. First-Best and Social Planner’s Equilibria

In this section, we first study the first-best equilibrium of the model. This provides a benchmark against which to judge the social planner’s equilibria with and without licensing. To contain the analysis, we only study licensing by fixed fees.

3.A.1. First-Best Equilibrium

The first-best equilibrium follows from maximizing individuals’ utility in (3.1) subject to the resource constraint in the economy. As seen above, available resources consist of the total production of traditional goods, which equals \( l \), aggregate labor supply. An amount \( z \) of traditional goods is then consumed directly by individuals. The final production of innovative goods requires inputs equal to \( \int_0^{c_H} x_c dc \). Investments in the innovation stage amount to \( \int_0^{c_L} c dc + \int_{c_L}^{c_H} \frac{c}{\varphi(R)} dc \), where the first term comprises innovation costs of firms not using the technology and the second term stands for innovation costs of firms that use the technology. Finally, the research institute applies a quantity \( R \) of the traditional good in its research process. The resource constraint is thus

\[
z + \int_0^{c_H} x_c dc + \int_0^{c_L} c dc + \int_{c_L}^{c_H} \frac{c}{\varphi(R)} dc + R = l.
\]

Solving the constraint for \( z \) and substituting the corresponding expression into the utility function given in (3.1) leads to the following necessary conditions for a maximum\(^\text{13}\)

\[
x_c : \quad u'(x_c) - 1 = 0 \quad \text{(3A.1a)}
\]
\[
l : \quad -e'(l) + 1 = 0 \quad \text{(3A.1b)}
\]
\[
R : \quad \int_{c_L}^{c_H} \frac{c}{[\varphi(R)]^2} \varphi'(R) dc - 1 = 0 \quad \text{(3A.1c)}
\]
\[
c_L : \quad -c_L + \frac{c_L}{\varphi(R)} = 0 \quad \text{(3A.1d)}
\]
\[
c_H : \quad u(x_{c_H}) - x_{c_H} - \frac{c_H}{\varphi(R)} = 0. \quad \text{(3A.1e)}
\]

\(^{13}\text{We assume that starting out from } R = 0, \text{ the initial gains from the institute’s technology are high enough to compensate the initial costs in condition (c). This guarantees that an interior solution for } R \text{ is established.} \)
Condition (a) states that at the optimal consumption level for each innovative good, marginal utility is equal to the cost of producing one unit of the respective version, which is 1 (or one unit of the traditional good) for each variety. The first-best consumption level $\tilde{x}$ is therefore the same for all brands of innovative goods.\textsuperscript{14} According to (b), the labor input should be chosen such that the marginal disutility of labor for the individual is equal to labor’s marginal product of 1. The optimal level of research output is determined in condition (c), which corresponds to the Samuelson condition for the provision of public goods (cf. Samuelson, 1954): the sum of marginal reductions in innovation costs due to an increase in the research output must just outweigh the marginal increase in input costs for research. From condition (d) we see that in the first-best equilibrium, all innovating firms use the cost-reducing technology, i.e. $\tilde{c}_L = 0$. The eventual number of innovating firms $\tilde{c}_H$ is determined by condition (e). For the last firm entering the sector, the social surplus out of consumption of its particular brand must be equal to the firm’s effective innovation costs. The five conditions in (3A.1) fully characterize the first-best equilibrium. However, the social planner may face restrictions in the financing of the expenditures for research that prevent him from attaining the first-best equilibrium. We next analyze the social planner’s problem in the two policy scenarios of no-licensing and licensing by fixed fees.

\textbf{3.A.2. Social Planner’s Equilibrium without Licensing}

Without licensing, the institute’s research activities must be paid for by a government transfer, which must itself be financed by taxes on labor income. The social planner cannot observe the hours worked by an individual, but only total labor income. Therefore, he cannot directly influence individuals’ labor supply, but only indirectly via the choice of the tax rate $t$. Given a certain tax rate, the individuals then adjust their labor supply $l(t)$ optimally as in Section 3.3.1, with $l'(t) < 0$. When deciding on the magnitude of research funding, the social planner has to take this distortionary effect of labor income taxation into account. The planner’s maximization problem is thus

$$
\max_{\tilde{x}, t, R, \tilde{c}_L, \tilde{c}_H, \lambda} \int_{0}^{\tilde{c}_H} (u(x_c) - x_c)dc - e(l(t)) + (1 - t)l(t) - \int_{0}^{\tilde{c}_L} cd\gamma(c) + \int_{\tilde{c}_L}^{\tilde{c}_H} \frac{c}{\varphi(R)}dc + \lambda[l(t) - R].
$$

\textsuperscript{14}The tilde denotes optimal values in the first-best equilibrium.
The first order conditions for a maximum are

\[ x_c : \quad u'(x_c) - 1 = 0 \quad (3A.2a) \]

\[ t : \quad -l(t) + \lambda(l(t) + tl'(t)) = 0 \quad (3A.2b) \]

\[ R : \quad \int_{cL}^{cH} \frac{c}{\varphi(R)} \varphi'(R) dc - \lambda = 0 \quad (3A.2c) \]

\[ c_L : \quad -c_L + \frac{c_L}{\varphi(R)} = 0 \quad (3A.2d) \]

\[ c_H : \quad u(x_{cH}) - x_{cH} - \frac{c_H}{\varphi(R)} = 0 \quad (3A.2e) \]

\[ \lambda : \quad tl(t) - R = 0. \quad (3A.2f) \]

The optimality conditions for \( \hat{x}^N, \hat{c}_L^N \) and \( \hat{c}_H^N \) are not altered relative to the first-best equilibrium.\(^{15}\) In \( \hat{x}^N \) and \( \hat{c}_L^N \) the social planner even attains the first-best values. So again all firms in the innovative sector make use of the research institute’s technology to reduce their development costs for new products. Due to the non-rivalness of the technology, a restriction of its application would unambiguously reduce social welfare. However, the total number of innovating firms, \( \hat{c}_H^N \), is changed because of its dependence on the research output. Applying the specific functional form for \( e(l) \) given in Section 3.3.4, condition (b) implies \( \hat{\lambda}^N = \frac{1}{1-NR^\varepsilon} \). Because of the distortion in the labor supply, the shadow price of one unit of research inputs is higher than one. Condition (c) now expresses the modified Samuelson rule for the provision of a public good: the marginal costs of research creation do not only include the technical input costs of 1, but contain also the costs associated with the funding of the respective expenses. Consequently, optimal research output \( \hat{R}^N \) and the optimal number of innovative firms \( \hat{c}_H^N \) are lower than in the first-best equilibrium. Finally, the condition (f) determines the level of the tax rate \( \hat{t}^N \) that is necessary to cover research expenditures.

\(^{15}\)The ‘hat’ stands for optimal values in the social planner’s equilibrium, and the superscript \( N \) again refers to the no-licensing scenario.

When both taxation and the generation of license revenues are available to fund research expenditures, the social planner’s optimization problem is

\[
\max_{x_c, t, f, R, c_L, c_H} \int_0^{c_H} (u(x_c) - x_c) dc - e(l(t)) + (1 - t)l(t) - \int_0^{c_L} c dc - \int_{c_L}^{c_H} \left( \frac{c}{\varphi(R)} + f \right) dc
\]

s.t. \( tl(t) + f(c_H - c_L) - R \geq 0; \quad x_c, t, f, R, c_L, c_H \geq 0. \)

It can be shown easily that when the social planner can charge license fees, research will be financed only by these license revenues. Essentially, the license fees are transfers of traditional goods from firms (or individuals, respectively) to the research institute. Thus, in contrast to the labor income tax, they do not imply an excess burden. Consequently, in this case, the social planner is able to attain the first-best equilibrium.

3.B. Research in Centralized vs. Decentralized Equilibria

This section proves that the optimal levels of research inputs \( R \) from the decentralized equilibria are lower than their social planner counterparts. In the licensing scenario, we again focus only on licensing by fixed fees \( f \).

3.B.1. Proof of \( R^N < \hat{R}^N \)

In this section, we prove that \( R^N < \hat{R}^N \) \( \forall \eta \in (1, \infty), \ A > 0 \). We therefore compare the optimality conditions that determine the corresponding values. In the equation system (3A.2), inserting the optimal expressions for \( \hat{x}^N, \hat{c}_N^L \) and \( \hat{c}_N^H \) into the condition for \( \hat{R}^N \) and solving the integral gives

\[
\frac{1}{2} A^2 \frac{1}{(\eta - 1)^2} \varphi'(\hat{R}^N) = \frac{1}{1 - \frac{r^N}{1 - \lambda^N} \varepsilon}. \tag{3A.3}
\]

Analogously, by inserting the specific expressions for \( c_H^N, \pi, CS \) and \( \lambda^N \) and solving the integral, we get for condition (3.9) in the decentralized equilibrium

\[
\frac{A^2}{(\eta - 1)^2} \left( \frac{\eta - 1}{\eta} \right)^{2\eta} \left( \frac{1}{2} + \frac{\eta}{\eta - 1} \right) \varphi'(R^N) = \frac{1}{1 - \frac{r^N}{1 - \lambda^N} \varepsilon}. \tag{3A.4}
\]
As the dependence of $R$ on $G$ and thus on the tax rate $t$ is the same in the decentralized and the social planner’s no-licensing equilibria, the right-hand sides of these conditions are equal, increasing functions of research output $R$. The left-hand sides of conditions (3A.3) and (3A.4), on the other hand, are both decreasing functions of $R$ as we have assumed $\varphi''(R) < 0$. We show that the function implied by the left-hand side of the social planner’s condition lies above the function arising from the left-hand side in decentralized decision making, i.e. the difference between the respective functions is positive, and therefore $R^N < \hat{R}^N$ for all admissible values of the price elasticity of demand $\eta$.

In particular, we prove that for a given level of $R$ and for all $\eta \in (1, \infty)$ the following condition holds:

$$
\zeta(\eta) \equiv \frac{A^2 \varphi'(R)}{2(\eta - 1)^2} \left(1 - \frac{3\eta - 1}{\eta - 1} \left(\frac{\eta - 1}{\eta}\right)^{2\eta}\right) > 0 \quad \forall \ \eta \in (1, \infty). \tag{3A.5}
$$

First of all, note that in the limits, we have $\lim_{\eta \to 1} \zeta(\eta) = \infty$ and $\lim_{\eta \to \infty} \zeta(\eta) = 0$. Thus, it is sufficient that $\zeta(\eta)$ is monotonously decreasing. The first factor in $\zeta(\eta)$ is obviously decreasing in $\eta$. If the second factor is also monotonously decreasing, (3A.5) is fulfilled (this condition is actually stricter than necessary). Thus, it remains to be shown that the derivative of the second factor with respect to $\eta$ is negative everywhere on its domain, i.e.

$$
\frac{2}{(\eta - 1)^2} \left(\frac{\eta - 1}{\eta}\right)^{2\eta} \left(2 - 3\eta + (1 - 4\eta + 3\eta^2) \log\left(\frac{\eta}{\eta - 1}\right)\right) < 0 \quad \forall \ \eta \in (1, \infty).
$$

The first two factors in this expression are strictly positive, thus the third factor must be negative. Essentially, $\theta(\eta)$ consists of a negative part, $2 - 3\eta$, and a positive part, $(1 - 4\eta + 3\eta^2) \log\left(\frac{\eta}{\eta - 1}\right)$, where $\log\left(\frac{\eta}{\eta - 1}\right)$ can be interpreted as a weighting factor. This weight must therefore be sufficiently small to ensure that the negative part dominates the positive part for all $\eta \in (1, \infty)$. Note that $\log\left(\frac{\eta}{\eta - 1}\right) = \log(\eta) - \log(\eta - 1)$ is the slope of the secant that crosses the log-function at $\eta - 1$ and $\eta$. The concavity of the log-function implies that the tangent of the function in $\eta - 1$ is steeper and the tangent in $\eta$ is flatter than the secant: $\frac{1}{\eta - 1} > \log(\eta) - \log(\eta - 1) > \frac{1}{\eta}$. Substituting the derivatives at the different points for $\log(\eta) - \log(\eta - 1)$ in $\theta(\eta)$ gives

$$
2 - 3\eta + (1 - 4\eta + 3\eta^2) \frac{1}{\eta - 1} = 1 \quad \text{and} \quad 2 - 3\eta + (1 - 4\eta + 3\eta^2) \frac{1}{\eta} = \frac{1}{\eta} - 2.
$$
So it is not a priori clear whether $\theta(\eta)$ is positive or negative. However, as the derivative of the log-function is continuous and monotonously decreasing, we know that there is one point between $\eta - 1$ and $\eta$, called $\eta - \sigma$ with $0 < \sigma < 1$, for which $2 - 3\eta + (1 - 4\eta + 3\eta^2) \frac{1}{\eta - \sigma} = 0$. Solving this equation gives $\sigma = \frac{2\eta - 1}{3\eta^2}$. If the slope of the secant, $\log(\eta) - \log(\eta - 1)$, is lower than the derivative of the log-function at $\eta - \sigma$, it follows that $\theta(\eta) < 0$ on the whole domain. At the limits, we get

$$\lim_{\eta \to 1} \log \left( \frac{\eta}{\eta - 1} \right) - \frac{1}{\eta - \frac{2\eta - 1}{3\eta^2}} = -\infty \quad \text{and} \quad \lim_{\eta \to \infty} \log \left( \frac{\eta}{\eta - 1} \right) - \frac{1}{\eta - \frac{2\eta - 1}{3\eta^2}} = 0.$$ 

In addition, the difference increases monotonously, as its derivative is $\frac{1 + \eta(3\eta - 2)}{\eta(1 - 4\eta + 3\eta^2)} > 0 \ \forall \ \eta \in (1, \infty)$. Thus, the difference in slopes is always negative, and $\log \left( \frac{\eta}{\eta - 1} \right)$ therefore sufficiently small that $\theta(\eta)$ is negative on its whole domain. This completes the proof.

### 3.B.2. Proof of $R^F < \hat{R}^F$

To compare the optimal values of research inputs under licensing by fixed fees, we compare the optimality conditions for $R$ from (3.11) and (3A.1). After inserting the corresponding expressions for $c_L, c_H$ etc. and solving the integrals, the conditions are given by

$$\hat{R}^F: \quad \frac{1}{2} \frac{A^2}{(\eta - 1)^2} \varphi'(\hat{R}^F) = 1$$

$$R^F: \quad \frac{A^2}{(\eta - 1)^2} \left( \frac{\eta - 1}{\eta} \right)^{2\eta} \left( \frac{1}{8} + \frac{\eta}{2(\eta - 1)} + \frac{1}{4} \frac{1 - t^F}{1 - t^F \varepsilon} \right) \varphi'(R^F) = \frac{1}{1 - \frac{t^F}{1 - t^F \varepsilon}}. \quad (3A.6)$$

Multiplying the condition for $R^F$ by $\left( 1 - \frac{t^F}{1 - t^F \varepsilon} \right)$ makes the right-hand sides equivalent. The left-hand side of the condition for $R^F$ then yields

$$\frac{A^2 \varphi'(R^F) \left( \frac{\eta - 1}{\eta} \right)^{2\eta} \left( \frac{1}{8} + \frac{\eta}{2(\eta - 1)} \right) \left( 1 - \frac{t^F}{1 - t^F \varepsilon} \right) + \frac{1}{4} \right) < \frac{A^2 \varphi'(R^F) \left( \frac{\eta - 1}{\eta} \right)^{2\eta} \left( \frac{1}{8} + \frac{\eta}{2(\eta - 1)} + \frac{1}{4} \right)}{(3A.7)}$$

\[16\] Remember that the social planner attains the first-best equilibrium when licensing is possible.
whenever $t^F > 0$. It is thus sufficient that the expression on the second line in (3A.7) is always lower than the left-hand side of the condition for $\hat{R}^F$, i.e.

$$\frac{A^2 \varphi'(R)}{2(\eta - 1)^2} \left( 1 - \frac{7\eta - 3}{4(\eta - 1)} \left( \frac{\eta - 1}{\eta} \right)^{2\eta} \right) > 0 \quad \forall \ \eta \in (1, \infty). \quad (3A.8)$$

Having shown in Appendix 3.B.1 that $\zeta(\eta) > 0$ for all $\eta \in (1, \infty)$, it follows immediately that (3A.8) holds, and therefore $R^F < \hat{R}^F$.

3.B.3. Optimal Research Subsidy under Licensing by Equity Shares

The optimality condition for the research subsidy under licensing by equity shares follows from inserting for $s, \pi, c^S_L, c^S_H, CS$ and $\lambda^S$ into equation (3.16) and solving the integral. We finally get

$$\frac{A^2 \varphi'(R^S)}{(\eta - 1)^2} \left( \frac{\eta - 1}{\eta} \right)^{2\eta} \left( \frac{3}{4} - \frac{\varphi(R^S)}{2} + \frac{\eta}{\eta - 1} + \frac{2\varphi(R^S) - 1}{8} \frac{1}{1 - \frac{t^S}{1-t^S} \varepsilon} \right) = \frac{1}{1 - \frac{t^S}{1-t^S} \varepsilon}. \quad (3A.9)$$
Chapter 4

Outsourcing, Unemployment and Welfare Policy

Christian Keuschnigg and Evelyn Ribi

The chapter investigates the consequences of outsourcing of labor intensive activities to low-wage economies. This trend challenges the two basic functions of the welfare state, redistribution and social insurance when private unemployment insurance markets are missing. The main results are: (i) outsourcing raises unemployment and labor income risk of unskilled workers; (ii) it increases inequality between high- and low-income groups; and (iii) the gains from outsourcing can be made Pareto improving by using a redistributive linear income tax if redistribution is initially not too large. We finally derive the welfare optimal redistribution and unemployment insurance policies.

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4.1. Introduction

As international integration proceeds, large firms find it increasingly easy to outsource the production of labor intensive components. This trend is especially pronounced in small European countries; in the Netherlands, Denmark, and Sweden, the value of goods outsourced abroad as a share of domestic demand was close to 50% in 2000, and it even approached 60% in Belgium and Austria (OECD, 2007b). An important motivation is to exploit cost advantages. Imports from low-wage countries have thus substantially increased. For instance in the UK, the share of imports from developing countries has risen from 18% to 22% of total imports in the period 1982-96 (Hijzen, Görg, and Hine, 2005). This trend seems to have accelerated most recently. Over 1995-2004, imports from non-OECD countries have grown substantially faster than imports from OECD countries in most manufacturing sectors in France, Germany, Japan, UK and the US (OECD, 2007b).

Integration undoubtedly generates substantial gains on average. The benefits and costs, however, are unevenly distributed. The cost savings from outsourcing raise profits for shareholders. But asset wealth and profit income is concentrated among top income earners. For the US, Wolff (1998) reports that more than 90% of financial wealth is held by the top 20% over the years 1983-1995. This high concentration of wealth is also found in other OECD countries (see Burniaux, Dang, Fore, Förster, Mira d’Ercole, and Oxley, 1998). Unskilled workers cannot benefit from higher profits since their asset ownership is insignificant. In addition, outsourcing of labor intensive components worsens their labor market prospects, see Feenstra and Hanson (1996) for the US, Anderton and Brenton (1999) and Hijzen, Görg, and Hine (2005) for the UK, Strauss-Kahn (2003) for France, Ekholm and Hakkala (2006) for Sweden and Falk and Wolfmayr (2008) for several EU countries. In general, outsourcing reduces demand for low-skilled workers, which translates into lower wages and higher unemployment. According to OECD (2007a), the average unemployment rate in 2005 among individuals with less than upper secondary education amounts to 12.4% in European OECD countries, whereas people with upper secondary (tertiary) education face much lower unemployment rates of 6.4% (4.0%). Unskilled workers are clearly exposed to much greater income risk than skilled workers. In sum, globalization enhances income inequality and exacerbates the income risk of low-skilled workers. It thereby creates “more demand” for the basic functions of the welfare state, consisting of social insurance in the absence of private unemployment insurance, and redistribution.
However, the welfare state itself creates part of the problem. Estimates of the elasticity of reservation wages with respect to unemployment benefits range from 0.11-0.17 (Lancaster and Chesher, 1983) to values around 0.4 (Feldstein and Poterba, 1984; Fishe, 1982; Van den Berg, 1990). The high benefits in Europe (replacement rates are mostly 60% or more, see OECD, 2004) thus significantly inflate wages. Díaz-Mora (2008) estimates that a 1% increase in firms’ domestic labor cost boosts the volume of outsourcing by 0.3%, and adds to outsourcing at the extensive margin by significantly raising the probability that a firm engages in subcontracting (Díaz-Mora and Triguero-Cano, 2007). Foreign countries with lower unit labor costs attract more outsourcing (Egger and Egger, 2003). We conclude that the welfare state tends to accelerate outsourcing by raising wages.

The paper investigates the consequences of outsourcing for welfare policies in high-wage economies. The theoretical model is based on two main assumptions, inspired by the stylized facts: the risk of unemployment falls on unskilled workers while firm ownership and profit income are concentrated among top earners. We consider the insurance and redistribution functions with two policy instruments, a linear income tax redistributing from high- to low-skilled workers, and unemployment insurance. The main results are: (i) Outsourcing, induced by lower transport costs, depresses wages and raises low-skilled unemployment; (ii) It raises inequality; (iii) Social insurance boosts wages and leads to more outsourcing and unemployment; (iv) Redistribution, in contrast, reduces gross wages and unemployment of unskilled workers. By reducing the net tax on employed unskilled workers, the linear income tax acts as a wage subsidy. It allows for higher net and lower gross wages, and thus favors domestic employment over outsourcing; (v) Keeping insurance constant, it is possible to use the income tax to distribute the gains from outsourcing in a Pareto improving way if tax rates are not too high. We finally characterize welfare optimal redistribution and insurance policies.

The paper is most closely related to the literature on integration and labor market performance, using models ranging from classical labor supply with full employment (e.g. Spector, 2001; Guesnerie, 2001), to search generated unemployment (e.g. Davidson, Martin, and Matusz, 1999; Davidson and Matusz, 2006; Davidson, Matusz, and Shevchenko, 2008) and unemployment from fair wage constraints (e.g. Egger and Kreickemeyer, 2009, 2008). This paper relies on a simple static model of search unemployment because the search framework is most commonly used in empirical labor market research (cf. Krueger and Meyer, 2002; Eckstein and van den Berg, 2007) and in the literature on optimal unemployment insurance.
(Chetty, 2006; Gruber, 1997; Baily, 1978, among others). Although these models differ in some predictions, they share common features that are central in our model to determine unemployment and outsourcing, such as a negative relationship between wages and unemployment (see, e.g. Egger and Kreickemeier, 2008, p. 177), the simultaneous increase in profits and unemployment in response to globalization, and the tax shifting behavior so that a higher replacement rate raises producer wages and thereby leads to more unemployment (see, e.g. Egger and Kreickemeier, 2009, p. 4 and proposition 2, and 2008, p. 129). Our paper also includes a stylized analysis of wage and employment subsidies as in Davidson, Martin, and Matusz (1999) because the progressive income tax redistributes from high- to low-skilled workers and, in reducing the wage tax, makes workers keener to accept job offers instead of staying unemployed.¹

Spector (2001) studied whether a non-linear income tax can make trade liberalization a Pareto-improvement.² The key difference is that we combine unemployment and, thus, discrete labor supply of unskilled with intensive supply of high-skilled workers. This links our paper to the income tax literature with discrete labor supply (Immervoll, Kleven, Kreiner, and Saez, 2007; Blundell, 2006; Saez, 2002, among others). Saez (2002) has shown that the relative strength of the intensive and extensive responses is important in the design of optimal tax transfer schedules. The extensive margin dominates at the low end of the income distribution and can rationalize an earned income tax credit (EITC) or a wage subsidy. Eissa and Hoynes (2006) consistently find for the US that the EITC strongly increases participation while the intensive response is insignificant for low-income earners.

Our key contribution is to introduce risk-aversion. All of the papers mentioned above assume risk-neutrality and focus on the redistributive and efficiency effects. Our paper thus complements this literature by introducing gains from insurance when private unemployment insurance is not possible. We believe that this extension is necessary to evaluate both functions of the welfare state, social insurance in addition to redistribution, and it is crucial for one of our central results: globalization raises the labor income risk of unskilled workers so that governments should expand the welfare state to provide better insurance. This is consistent with the empirical finding of Rodrik (1998) that high-income countries with a larger degree

¹In using a dynamic search framework, these authors can address sectoral labor reallocation, allowing them to distinguish between employment and wage subsidies to specifically target stayers and movers.
²We use a linear income tax. We are not aware of any paper that is able to deal with non-linear income taxation when there is unemployment and profit on top of wage income. Imposing incentive compatibility conditions in non-linear income taxation tends to restrict somewhat the possibility for redistribution.
of openness and exposure to external risk have significantly larger social security and welfare spending.

In the rest of the paper, Section 4.2 sets up the analytical model. Section 4.3 derives the effects of globalization and national welfare policies. Section 4.4 shows how the linear income tax can possibly distribute the gains from outsourcing in a Pareto improving way, and characterizes the optimal structure of insurance and redistribution policies. Section 4.5 concludes. The Appendix contains some technical calculations.

4.2. A Simple Model

The world economy consists of a high- and low-wage country, North and South. The North is endowed with a mass 1 of unskilled and a mass $N$ of skilled agents. Firms supply a homogeneous *numéraire* good in two alternative sectors. Our main focus is on the innovative sector where firms combine high- and low-tech inputs to manufacture the final good. In the alternative sector, the final good can be produced with a linear technology using only skilled labor. The South is endowed with low-skilled labor only which is employed in a linear production process with a low, fixed wage.

4.2.1. Households

Agents are risk averse. Given wage $r$, skilled workers supply variable labor $H$ earning an hourly wage $(1 - T)r$ net of tax. They also receive profits $\bar{\pi} = \Pi/N$ per capita where $\Pi$ is aggregate profits. Assuming linearly separable preferences, welfare $V_H$ (index $H$ for high-skilled) is a concave increasing function of income $c_H$ minus effort costs $\varphi (H)$,

$$V_H = \max_{H} u (c_H - \varphi (H)), \quad s.t. \quad c_H = (1 - T)r_H + \bar{\pi}. \quad (4.1)$$

Given convex increasing effort costs, skilled labor supply increases with the net wage, $(1 - T)r = \varphi' (H)$. Income effects are excluded.

Unskilled workers supply one unit of labor at a gross wage $w$, if employed. The ex ante probability of being unemployed $1 - e$ is equal to the ex post unemployment
rate. Expected utility is

$$V_L = e \cdot u(w - \tau) + (1 - e) \cdot u(b + z). \quad (4.2)$$

To protect income, the welfare state pays a benefit $b$ in the event of unemployment which adds to the money equivalent value $z$ of leisure or home production (see Blanchard and Tirole, 2008). Benefits are financed by contributions and are possibly cross-subsidized by skilled workers. The total tax per capita is $\tau$, reflecting the net tax liability of a linear income tax plus the contribution to the unemployment insurance (UI) scheme.

### 4.2.2. Firms

**Technology:** A high-skilled agent can either produce one unit of the high-tech input, or $r$ units of the final good in the alternative sector. Being fully mobile across sectors, she must be paid a fixed wage $r$. A low-skilled worker can only produce one unit of the low-tech input without any other option. Both inputs are combined in the innovative sector to assemble the final output good. We make three important assumptions with respect to the innovative technology. First, production is decreasing returns to scale, due to the presence of a fixed factor, reflecting unique know-how or a limited span of managerial control as in Lucas (1978). We assume that there is a mass one of innovative firms and that each one makes strictly positive profits $\pi$, reflecting the returns to the fixed factor. Second, we assume that the innovative technology is stochastic and requires a fixed investment $f$. Given type $q' \in [0, 1]$, investment succeeds with probability $q'$, yielding profit $\pi$. With probability $1 - q'$, the firm fails and is closed down. The cumulative distribution of firms is $G(q) = \int_0^q g(q')dq'$. Firm heterogeneity in success probabilities replaces the variation in factor productivity in the literature inspired by Melitz (2003). In our model, all firms are symmetric within each group (integrated versus outsourcing firms) which is a major simplification compared to Melitz-style heterogeneous firm models.

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4See also Keuschnigg (2008). A drawback is that we cannot make statements how the changing composition of the business sector affects average factor productivity within each group of outsourcing and integrated firms. We believe that this is not crucial for the policy issues analyzed in this paper. Note, however, that even in our model production costs differ across groups.
Third, innovative firms choose an organizational form. An integrated firm produces low- and high-tech inputs in-house, earning profits $\pi$. Alternatively, production of low-tech inputs is outsourced to independent suppliers in the South. Despite transport costs of shipping inputs back home, we assume the wage advantage of the South to be so large that outsourcing is a cost reducing strategy and yields higher profits than integration, $\pi^o > \pi$. However, the parent firm must first find a suitable, independent subcontractor, transfer the technological specifications of the required input and possibly assist in preparing production. Hence, outsourcing requires a higher fixed cost $f^o > f = 0$, where the integration cost is normalized to zero for simplicity. The net expected value of a type $q'$ firm is $\pi^o q' - f^o$ with outsourcing and $\pi q'$ with integration. Once the fixed cost investment is successfully completed, firms are fully symmetric within each group, earning profits of either $\pi^o$ or $\pi$. In the following, a firm specific variable without an index refers to integrated firms, an upper index $o$ refers to outsourcing firms.

The sequence of events is: (i) a mass one of firms is started, each drawing a success probability $q'$;\(^5\) (ii) firms choose organizational form and invest the fixed cost; (iii) a firm succeeds with probability $1 - q'$, the firm fails and closes down; (iv) if successful, firms start production. The model is solved backwards.

At production stage, a successful firm acquires high- and low-tech inputs, $h$ and $l$, to produce raw value added $y$ which is transformed into final output subject to decreasing returns to scale. The total technology is homothetic,

$$x = F(h, l) = f(y(h, l)), \quad f(y) = A \cdot y^\delta, \quad y = h^{1-\alpha}l^\alpha, \quad 0 < \alpha, \delta < 1. \quad (4.3)$$

Since $y$ is linear homogeneous, the cost per unit of value added $\omega(r, W)$ depends on prices but not on scale. The factor price $W$ not only includes the wage but also some recruitment cost, see below. Profit maximization $\pi(\omega) = \max_y x - \omega y$ s.t. $x = f(y)$ gives

$$f'(y) = \omega, \quad \omega(r, W) = \min_{\tilde{h}, \tilde{l}} r\tilde{h} + W\tilde{l} \quad \text{s.t.} \quad \tilde{h}^{1-\alpha} \tilde{l}^\alpha \geq 1. \quad (4.4)$$

Value added $y$ and output $x$ depend on unit factor cost. Multiplying by $y$ gives $\omega y = yf'(y) = \delta x$ since the output elasticity $\delta$ is constant by assumption. Total profits are thus proportional to sales, $\pi = x - \omega y = (1 - \delta)x$. Factor demand is unit demand scaled by value added output, $h = \tilde{h}y$ and $l = \tilde{l}y$, giving total

\(^5\)We do not consider endogenous entry (see eq. 11 in Antràs and Helpman, 2004, where entry results from R&D decisions) but take the range of ideas for innovative firms as given.
cost \( \omega y = rh + Wl \). The Cobb Douglas technology implies constant cost shares, \( Wl = \alpha \cdot \delta \) and \( rh = (1 - \alpha) \cdot \delta \).

**Vertical Integration:** Integrated firms produce the low-tech input in-house by hiring unskilled workers on a search labor market. A firm announcing \( k \) vacancies is able to hire \( l = mk \) workers. Maintaining a vacancy costs \( \kappa \) units of output. Once a suitably qualified worker is found, there is a job rent to be shared which is divided by Nash bargaining. For simplicity, we assume one shot matching so that no other search opportunity is available.

The firm needs \( h \) units of skilled labor and \( l \) units of unskilled labor. Anticipating the result of wage bargaining, it generates profits of

\[
\pi = \max_{h,k} x - rh - wl - \kappa k, \quad \text{s.t.} \quad l = m \cdot k, \quad x = F(h,l). \tag{4.5}
\]

The firm’s hiring results in the following job creation and labor demand conditions,

\[
(F_l - w) \cdot m = \kappa, \quad F_h = r. \tag{4.6}
\]

The market for skilled workers is competitive. Firms hire until marginal productivity is equal to the wage. With unskilled workers, the marginal cost of investing in a job vacancy must correspond to the expected job rent. Equivalently, the total cost of an unskilled worker, \( F_l = w + \kappa/m \equiv W \), exceeds the wage by a recruitment cost, which is equal to the search cost times the number of vacancies needed for a successful hire.

The wage follows from bargaining over the job rent. A worker moving out of unemployment gains \( w - \tau - b - z \), see (4.2). Given the workers’ bargaining power \( \gamma \), Nash bargaining \( \max_w [u(w - \tau) - u(b + z)]^{\gamma} [F_l - w]^{1-\gamma} \) yields

\[
(1 - \gamma) [u(w - \tau) - u(b + z)] = \gamma u'(w - \tau)(F_l - w). \tag{4.7}
\]

**Outsourcing:** Production of low-tech inputs may be outsourced to the South where the wage rate is fixed to a low \( w^s \). Given constant labor productivity, subcontractors must earn \( w^s \) per unit to break even.\(^6\) However, shipping back to

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\(^6\)We close the model in a Separate Appendix (www.alexandria.unisg.ch/publications/41122). The South is endowed with unskilled labor, producing either final output or subcontracting. Constant labor productivity and perfect mobility imply a fixed wage.
Northern manufacturers loses \((\lambda - 1) l^s\) in cross border transport. The subcontractor must thus produce \(\lambda l^s, \lambda > 1\), if the manufacturer needs a quantity \(l^s\). The zero profit price for outsourced inputs is assumed to be lower than the Northern factor cost, \(\lambda w^s < W\).

An outsourcing firm in the North employs skilled labor to produce the high-tech input in-house. By combining them with low-tech imports from the South, it assembles final output and earns a profit

\[
\pi^o = \max_{l^o, l^s} x^o - r h^o - \lambda w^s l^s, \quad \text{s.t.} \quad x^o = F (h^o, l^s). \tag{4.8}
\]

The optimal choice of inputs satisfies

\[
F_{h^o} = r, \quad F_{l^s} = \lambda w^s. \tag{4.9}
\]

Replacing the factor price \(W\) by \(\lambda w^s\) in (4.3) and (4.4), we obtain unit cost \(\omega^o (r, \lambda w^s)\) under outsourcing, yielding value added \(y^o\), output \(x^o\) and profit \(\pi^o = (1 - \delta) x^o\). The Cobb Douglas technology implies constant cost shares so that \(\lambda w^s l^s = \alpha \cdot \delta x^o\).

**Organizational Choice:** Due to the cost advantage \(\lambda w^s < W\), profits from outsourcing are larger once the fixed cost \(f^o\) is sunk. At the beginning, a firm of type \(q'\) chooses the organizational form which yields the highest expected present value. Outsourcing is preferred if \(q' \pi^o - f^o > q' \pi\), i.e. when the expected profit differential exceeds the fixed cost of outsourcing, \(q' (\pi^o - \pi) > f^o\). The critical firm is thus identified by

\[
q \cdot (\pi^o - \pi) = f^o. \tag{4.10}
\]

Firms with high success probabilities \(q' > q\) prefer outsourcing. Figure 4.1 illustrates the choice of organizational form.

Innovative firms are independently distributed with density \(g(q')\). The critical type in (4.10) determines the fraction of integrated \((s)\) and outsourcing \((s^o)\) firms,

\[
s = \int_0^q q' dG(q'), \quad s^o = \int_q^1 q' dG(q'), \quad s^f = \int_q^1 dG(q'). \tag{4.11}
\]

Of all firms, \(s + s^o < 1\) survive to production stage while \(1 - s - s^o\) fail after fixed costs are sunk. A share \(s^f\) chooses outsourcing and invests \(f^o\), but only a share \(s^o < s^f\) actually makes it to production stage.

After success is realized, there are only two types of firms left in the innovative sector: vertically integrated and outsourcing firms. Given this symmetry, total
profits are

\[ \Pi = s\pi + s^0\pi^0 - s^f f^0. \]  \hspace{1cm} (4.12)

### 4.2.3. Equilibrium

The labor market for low-skilled workers and the government budget jointly determine equilibrium.\(^7\) Unskilled labor is subject to involuntary unemployment. Integrated firms post sk vacancies. Given a mass 1 of job searchers, labor market tightness, i.e. the ratio of vacancies to jobseekers, is \(\theta \equiv sk\). A linear homogeneous technology \(e = M(1, \theta) = m \cdot \theta\) determines matching rates \(e\) and \(m\) which satisfy \(e'(\theta) > 0 > m'(\theta)\). A tighter market increases workers’ chances to get a job but reduces chances of firms to fill vacancies. With hiring per firm equal to \(l = mk\), the matching equation reflects “market clearing”

\[ e = s \cdot l. \]  \hspace{1cm} (4.13)

Employment is equal to aggregate labor demand which reflects employment \(l\) per firm and the number \(s\) of (integrated) firms actually hiring locally. Adding the

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\(^7\)The standard sector produces with a linear technology using up all remaining skilled labor. A separate Appendix shows how trade balances and world output market equilibrium follow from Walras’ Law.
government budget constraint in the North closes the model,

\[ T \cdot rHN + \tau \cdot e = (1 - e) \cdot b. \]  

(4.14)

Equilibrium is brought about by values of an employment rate \( e \) (which is uniquely related to labor market tightness \( \theta \)), and a net tax \( \tau \) (consisting of the income tax plus unemployment insurance contribution) that simultaneously satisfy labor market clearing and fiscal budget balance.

The two policy instruments are UI benefits \( b \) and the tax rate \( T \) on the skilled, reflecting social insurance and redistribution policies: (i) Higher UI benefits are financed by rising contributions (as part of \( \tau \)). The government thereby shifts income from the good to the bad state and provides insurance to risk averse workers. Insurance need not be actuarially fair and might be cross-subsidized by the high-skilled. (ii) The government redistributes from high-wage earners to employed unskilled workers by raising the marginal tax rate \( T \) to finance a tax cut or a transfer to low-income individuals.\(^8\) There is no restriction on \( \tau \) being positive. A negative value corresponds to an earned income tax credit or a wage subsidy. Its main purpose is to boost labor market participation among the low-skilled by widening the income differential between work and unemployment.

### 4.3. Globalization and Welfare Policy

This section analyzes how economic equilibrium adjusts when transport costs \( \lambda \) fall as a result of globalization, or when the government reconsiders its redistributive or insurance policies by changing the tax rate \( T \) or benefits \( b \). We derive the comparative static effects of exogenous shocks on the equilibrating values of \( e(e; b, \lambda) \) and \( \tau(e; b, \lambda) \) by log-linearizing the model. The hat notation denotes percentage changes relative to initial values, e.g., \( \hat{e} \equiv de/e \). Exceptions to this definition are separately indicated.

#### 4.3.1. Outsourcing and Low-Skilled Labor

The supply side relates the employment rate \( e \) to market tightness \( \theta \) which reestablishes labor market equilibrium \( \varepsilon = sl \) in response to economic shocks. Increased

\(^8\)The tax liability under a linear income tax is \( \tau = T \cdot w - z \).
tightness raises the chances of workers to locate a job while it reduces the rate $m$ with which firms are able to fill vacancies. The matching function mentioned in (4.13) implies

$$\hat{e} = (1 - \eta) \hat{\theta}, \quad \hat{m} = -\eta \cdot \hat{\theta}, \quad \eta \equiv -\theta m'(\theta)/m(\theta) > 0. \quad (4.15)$$

On the demand side, outsourcing affects the extensive and intensive margins of labor demand, $L \equiv s_l$, reflecting employment per firm and the number of firms hiring at home. Log-linearizing the bargaining condition (4.7) in Appendix A1, leads to a wage response

$$\hat{w} = \hat{\tau} + \hat{b} + \frac{1 - \tau^* - z/w}{1 + \rho \chi} \cdot \frac{\eta}{1 - \eta} \hat{e}, \quad \tau^* \equiv \frac{\tau + b}{w}, \quad \hat{b} \equiv \frac{db}{w}, \quad \hat{\tau} \equiv \frac{d\tau}{w}, \quad (4.16)$$

where $\chi \equiv (w - \tau - b - z) / (w - \tau)$ measures the income gap between labor market states, and $\rho \equiv -cu''(c)/u'(c)$ is the degree of relative risk aversion. Finally, $\tau^*$ denotes the participation tax rate and, thus, the fiscal disincentive against accepting a job offer. This distortion tends to be high, easily exceeding 50% (see Immervoll, Kleven, Kreiner, and Saez, 2007, for evidence in Europe), since it is the sum of benefits lost and taxes paid on the job. If measured in percent of gross wage earnings, it corresponds to the sum of the average tax rate $\tau/w$ and the replacement rate in the unemployment insurance system, $b/w$.

A higher tax on work and a more generous UI benefit raise a worker’s reservation wage. Since her bargaining strength assures a strictly positive job surplus, any policy raising the reservation wage is partly shifted to firms and inflates gross wages.\(^9\) Bargaining implies that job rents of workers and firms must change in proportion. Given a wage increase, labor productivity must rise to an extent that also leaves a higher job rent to the firm. As firms expand hiring, employment and market tightness rise until the declining hiring probability satisfies again the job creation condition. In equilibrium, a higher employment rate is thus associated with a higher wage as in (4.16).

Labor demand per firm follows from $F_l = w + \kappa/m \equiv W$. Unit labor costs $W$ reflect wages plus recruitment costs $\kappa/m$ and increase by $\hat{W} \equiv \frac{w}{W} \cdot \hat{w} + \frac{\kappa/m}{W} \cdot \frac{\eta}{1 - \eta} \hat{e}$. When markets become tighter, firms need to post more vacancies per employee and incur higher recruitment costs. Substituting (4.16) yields the change in unit labor

\(^9\)Tax shifting is weakened when benefits are indexed to net wages. Some tax shifting will occur as long as wage indexation of benefits is not complete.
Employment per firm depends on output and wage costs relative to the price of skilled labor. Firms rationalize on the use of unskilled labor if its relative price increases. Apart from this substitution effect, higher unskilled labor cost feeds through on total cost $\omega(r, W)$ per unit of value added. Applying the envelope theorem to (4.4), the percentage change is $\dot{\omega} = \alpha \dot{W}$ where $\alpha = W\tilde{l}/\omega$ is the cost share of low-tech inputs. Total costs amount to $\omega y = Wl + rh$. The firm’s optimal output is given by $f'(y) = \omega$ and implies $\dot{y} = -\dot{\omega}/(1-\delta)$, which determines the supply of final goods, $\dot{x} = \delta \dot{y}$. Profits are a fixed proportion of sales, $\pi = x - \omega y = (1-\delta)x$, and thus change by

$$\hat{\pi} = \hat{x} = -\frac{\alpha \delta}{1-\delta} \cdot \hat{W}, \quad \hat{l} = -\left[1 + \frac{\alpha \delta}{1-\delta}\right] \cdot \hat{W}. \quad (4.18)$$

As the cost shares must be constant, the change in labor demand per firm follows from $\hat{l} = \dot{\omega} + \dot{y} - \dot{W}$. To sum up, a wage increase erodes profits, output and the demand for unskilled labor of integrated firms.

The extensive margin of labor demand reflects the share of firms opting for outsourcing and, thus, depends on relative profits. If cross-border transport costs decline, the import price $\lambda w^s$ paid by Northern companies falls and outsourcing becomes cheaper. Firms outsourcing to low-wage countries save costs, their sales and profits rise. Formally, unit costs are $\omega^o = \omega(\lambda w^s, r^o) = \lambda w^s\tilde{f} + r^o\tilde{h}$ and rise with transport cost by $\dot{\omega}^o = \alpha \dot{\lambda}$. For final assembly, we have $\dot{x}^o = \delta \dot{y}^o$ and $\dot{\omega}^o = -(1-\delta) \dot{y}^o$ as before. Therefore,

$$\hat{\omega}^o = \hat{x}^o = -\frac{\alpha \delta}{1-\delta} \cdot \dot{\lambda}. \quad (4.19)$$

In raising wages, welfare policy reduces profits $\pi$ of integrated firms. Outsourcing becomes relatively cheaper. In Figure 4.1, the line through the origin rotates down so that a margin of firms switches to outsourcing. Labor demand shrinks in line with $s = \int q'dG(q')$. Similarly, a reduction of transport costs makes outsourcing more profitable and also erodes labor demand. Log-differentiating the discrete

\[10\] We adopt the convention of defining all coefficients such as $\psi$ to be positively valued.
organizational choice in (4.10) yields

\[ \hat{q} = -\frac{\pi \hat{q}^o - \pi \hat{q}}{\pi^o - \pi} = \frac{1}{\pi^o - \pi} \left( \lambda w^\ell \cdot \hat{\lambda} - Wl \cdot \hat{W} \right). \]  

(4.20)

The second equality follows upon substituting profit changes and using \( \pi = (1 - \delta) x \) as well as \( IW = a\delta x \). When outsourcing expands, labor demand falls by \( ds = qg(q) dq \) or

\[ s = \mu \cdot \left( \lambda w^\ell \cdot \hat{\lambda} - Wl \cdot \hat{W} \right), \quad \mu \equiv \frac{qg(q)}{s(q)} \frac{q}{\pi^o - \pi}. \]  

(4.21)

Aggregate labor demand changes by \( \hat{L} = \hat{l} + \hat{s} \). Upon substitution, we get

\[ \hat{L} = L_\lambda \cdot \hat{\lambda} - L_W \cdot \hat{W}, \quad L_\lambda \equiv \mu \lambda w^\ell, \quad L_W \equiv 1 + \frac{\alpha \delta}{1 - \delta} + \mu Wl. \]  

(4.22)

Combining this expression with (4.17) reveals how labor demand changes. Using \( \hat{\epsilon} = \hat{L} \), and solving for the employment rate yields the condition for labor market equilibrium \( \epsilon(\tau; b, \lambda) \),

\[ \hat{\epsilon} = \frac{1}{V} \frac{WL_\lambda}{wL_W} \cdot \hat{\lambda} - \frac{1}{V} \cdot \left( \hat{\tau} + \hat{\beta} \right), \quad V \equiv \frac{W}{wL_W} + \frac{\eta}{1 - \eta} \psi_e. \]  

(4.23)

To sum up, net taxes or benefits get partly shifted to employers, inflate costs and reduce labor demand of integrated firms. Since higher wages make integration less profitable, more firms shift to outsourcing. Unemployment among unskilled workers increases. A lower transport cost makes outsourcing more profitable and reduces national labor demand. Again, unemployment rises.

### 4.3.2. Fiscal Budget Balance

Redistribution implies a higher tax on high-skilled households, combined with a lower net tax \( \tau \) on the unskilled. Insurance calls for higher unemployment benefits, combined with a higher net tax on the employed unskilled workers. In both cases, the tax \( \tau \) on earnings of unskilled workers is endogenously set to balance the fiscal budget. Log-linearizing the budget constraint in (4.14) shows to which extent the net tax on the low-skilled must be adjusted. By (4.1), a higher tax rate \( T \) discourages hours worked of the skilled, \( \hat{H} = -\sigma \cdot \hat{T} \), where \( \sigma \equiv \phi' / (H \phi'') > 0 \) is the wage elasticity of labor supply. As usual, the change in the tax rate is expressed relative
to the tax factor, $\hat{T} \equiv dT / (1 - T)$. Using $\hat{b} \equiv (db) / w$ and $\hat{\tau} \equiv (d\tau) / w$ yields the budget in log-linearized form,

$$\hat{\tau} = \frac{1 - e}{e} \cdot \hat{b} - \left[ 1 - \frac{T}{1 - T^\sigma} \right] \frac{Y_H}{ew} \cdot \hat{T} - \tau^* \cdot \hat{e},$$  \hspace{1cm} (4.24)

where $Y_H \equiv (1 - T) rHN$ denotes aggregate net wage income of the high-skilled. For a given employment rate, higher benefits require higher contributions. In contrast, a higher tax on skilled workers allows to cut net taxes of unskilled workers.\(^{11}\) Increased employment creates a double fiscal gain proportional to the participation tax rate $\tau^*$ as more people switch from joblessness into employment.

### 4.3.3. Policy Effects

The equilibrium tax rate and market tightness must simultaneously satisfy labor market clearing and fiscal budget balance. Solving (4.23) and (4.24) yields

$$ew \cdot \hat{\tau} = \sigma_{ET} \cdot Y_H \hat{T} - \sigma_{EB} \cdot wb + \sigma_{E\lambda} \cdot eW\hat{\lambda},$$

$$ew \cdot \hat{\tau} = -\sigma_{ET} \cdot Y_H \hat{T} + (1 - e + \sigma_{EB} \tau^*) \cdot wb - \sigma_{E\lambda} \tau^* \cdot eW\hat{\lambda},$$  \hspace{1cm} (4.25)

where, for later use, the coefficients are defined as

$$\sigma_{EB} \equiv \frac{1}{\nabla - \tau^*} > 0, \quad \sigma_{ET} \equiv \left[ 1 - \frac{T}{1 - T^\sigma} \right] \sigma_{EB}, \quad \sigma_{E\lambda} \equiv \frac{L_{\lambda}}{L_W} \sigma_{EB}.$$

The determinant, $\nabla - \tau^* = 1 / \sigma_{EB} > 0$, must be positive to assure stability. Given stability, raising the tax rate on high wage earners allows to cut the net tax burden of unskilled persons, while more spending on insurance requires to raise the tax. The immediate effect of lower transport costs is an increase in profits $\pi^o$, leading more firms to switch to outsourcing which erodes labor demand. For given employment, domestic wages and labor costs are not immediately affected. However, to eliminate excess labor supply, market tightness must fall, leading to lower employment. More people claim benefits and fewer pay contributions. Consequently, the tax $\tau$ on employed workers must be raised to balance the budget (given that $T$ does not change). Globalization not only raises unemployment among the low-skilled but also reduces their wages.\(^{12}\) In contrast, per capita profit income increases for two reasons. First, cheaper low-tech imports directly boost profits of

\(^{11}\)At very high tax rates, revenue might decline as $1 - T \tau^\sigma$ becomes negative (Laffer curve effect). However, it would never be an optimal policy to raise the tax rate to a level where this could occur.

\(^{12}\)The effect is not entirely unambiguous since the necessary tax increase points in the opposite direction of...
outsourcing firms. Second, since more firms switch to outsourcing, the reduction in labor demand depresses wages, thereby strengthening profits of integrated firms. By (4.25) in combination with (4A.6) and (4A.7), the average per capita profit over all firms rises, and high-skilled capital owners gain. Globalization thus creates more inequality.

To fight increasing inequality, governments can redistribute by raising taxes on high-wage earners to finance a tax cut for low-income households. A lower tax helps to reduce unemployment among the low-skilled. The policy acts like a wage subsidy, allowing for higher net wages and lower gross wages, see (4A.5-4A.6). A lower wage bill boosts job creation and employment. It also boosts profits of integrated firms and thereby reduces the tendency towards outsourcing. This result points to the usefulness of policies to strengthen participation of the low-skilled in a globalized economy. Finally, although the skilled lose on account of a higher tax on labor income, they gain in terms of profits.

An central function of the welfare state is social insurance when private risk markets are missing. Our last experiment raises UI benefits and finances them with higher contributions which add to the overall tax burden \( \tau \) of the employed low-skilled. This way, the government allows risk averse workers to shift income from the good to the bad state, creating gains from insurance. Higher benefits boost workers’ reservation wages. The policy thereby discourages job creation and raises unemployment. In adding to firms’ wage costs, the welfare state reduces profits of integrated firms and induces more outsourcing, further raising unemployment. Via reduced profits, the high-skilled bear part of the burden.

4.4. Welfare and Optimality

How do globalization and public policy affect individual welfare in the presence of labor market distortions and missing insurance markets?

4.4.1. Efficiency and Redistribution

Skilled workers gain from higher profits but lose when labor taxes rise. Applying the envelope theorem to (4.1) yields \( NdV_H = u_H' \cdot (-Y_H \hat{\tau} + d\Pi) \). Define \( \hat{V}_H \equiv a higher wage. We give a sufficient condition assuring that the direct effect dominates over the induced tax effect. The condition by the way would also guarantee stability, see (4A.4) and (4A.6).
\(dV_H/u_H'\) and divide by marginal utilities to express welfare changes in money equivalent units. Add the profit change in (4A.7) and substitute the change in unit labor cost,

\[
N\hat{V}_H = -Y_H\hat{T} - e\hat{w}\hat{\omega} - \frac{\eta}{1-\eta} \frac{\kappa e}{m} - s^0 \lambda \omega^p \hat{\lambda}. \tag{4.26}
\]

Better access of industrialized countries to cheap labor in the South by means of lower transport costs \(\hat{\lambda} < 0\) boosts profits.

Welfare of unskilled workers changes by

\[
dV_L = u'_E \cdot e\hat{w}(\hat{\omega} - \hat{\tau}) + (u'_E - u'_B) e\hat{\epsilon},
\]

where lower indices \(E\) and \(B\) refer to the states ‘Employed’ and ‘on Benefits’. Write again \(\hat{V}_L \equiv dV_L/u'_L\). Substitute \(u'_B\) by the approximation in (4A.1) and \(u'_E - u'_B\) by the bargaining condition (4.7), with the job rent replaced by the job creation condition \((F_l - w)m = \kappa\), yielding, in money equivalent units,

\[
\hat{V}_L = (1-e)w\hat{b} + \rho \chi (1-e)w\hat{b} + e\omega(\hat{\omega} - \hat{\tau}) + \gamma \frac{\kappa e}{1-\gamma m} \hat{\epsilon}. \tag{4.27}
\]

The welfare change of unskilled workers partly reflects taxes and transfers. Replace the endogenous tax by the differential of the fiscal constraint in (4.24). Substitute (4.26) to compare with the welfare change of skilled households. Collecting terms and using \((F_l - w) = \kappa/m\) as well as \(\hat{T} = -\sigma \hat{T}\) leads to

\[
\hat{V} \equiv N\hat{V}_H + \hat{V}_L = \frac{T}{1-T}Y_H \cdot \hat{T} + e\hat{w}\Gamma \cdot \hat{\epsilon} + \rho \chi (1-e)w \cdot \hat{b} - s^0 \lambda \omega^p \hat{\lambda}, \tag{4.28}
\]

\[
\Gamma \equiv \tau^* + (\gamma - \eta) \cdot \frac{(F_l - w)/w}{(1-\eta)(1-\gamma)}.
\]

Welfare changes reflect redistribution and efficiency. Redistribution means that the welfare gain of one group is offset by an equal welfare loss of the other, leaving a net change \(\hat{V} = 0\). The skilled lose if they face a tax increase and if profits decline. A higher tax directly redistributes to the poor. Redistribution also occurs since a tighter labor market raises income and employment of the unskilled but cuts into profits due to increased hiring costs.

Efficiency effects, equal to the aggregate welfare change \(\hat{V}\) in (4.28), result from policy induced distortions and preexisting market failures. A higher marginal tax \(T\) creates the standard excess burden from distorting intensive labor supply. Expanding low-skilled employment yields efficiency gains proportional to \(\Gamma\). Part of the gain is proportional to the participation tax rate \(\tau^*\) in the sense of Saez (2002). When an individual switches from unemployment into a job, she pays taxes and loses benefits and thus incurs a total loss of \(\tau^*w \equiv \tau + b\). This loss
mirrors the double fiscal gain in terms of higher tax revenue and lower social spending. Participation taxes tend to be high for low-income earners in Europe, see Immervoll, Kleven, Kreiner, and Saez (2007). Being proportional to $\tau^*$, the excess burden from discouraging low-skilled employment could thus be substantial. The second term in $\Gamma$ relates to search frictions. When their bargaining power exceeds the matching elasticity of job search, $\gamma > \eta$, workers get a too high wage and thus a too high share of the job surplus, causing inefficiently high unemployment. Employment enhancing policies create first order welfare gains. If the search equilibrium were efficient in the sense of Hosios (1990), $\gamma = \eta$, there would also be no marginal gain from more employment.

The next term in (4.28) corresponds to gains from insurance. Social insurance is valuable for risk averse workers when markets are incomplete and private UI is not available. The gains are proportional to the unemployment rate times the product of the degree of risk aversion $\rho$ and the degree of income variation $\chi$. This term is known from Baily (1978), Gruber (1997) and Chetty (2006), among others. In these papers, all agents are symmetric so that there can be no welfare gains from redistribution but only from insurance. Our paper extends the analysis to an international context.

The last term in (4.28) captures the direct efficiency gains from globalization, reflecting the cost savings from better access to cheap labor in the South. Lower transport costs $\lambda$ reduce costs of firms outsourcing to low-wage economies. The net effect on welfare is $\hat{V} = e\omega \hat{\delta} - s^o \lambda \omega^s \hat{l} \hat{\lambda}$. It would be clearly positive if the welfare state were absent and labor markets were efficient, implying $\Gamma = 0$. The domestic employment effect of more outsourcing magnifies the welfare gains if the labor market is overly tight, $\gamma < \eta$. In contrast, if unemployment is inefficiently high, $\gamma > \eta$, the net impact tends to be ambiguous. The gains from lower transport costs would have to be set against the efficiency losses from higher unemployment. These efficiency losses are magnified if there is a high participation tax $\tau^*$ due to the existence of a welfare state.

### 4.4.2. Pareto Improving Policy

The basic functions of the welfare state are redistribution and social insurance. To analyze policy, we need the final welfare effects in general equilibrium. Policy
changes welfare of skilled households as in (4.26). Appendix A4 derives

$$N \hat{V}_H = -I_T \cdot Y_H \hat{T} - I_B \cdot w \hat{b} - (I_\lambda \cdot eW + s^0 \lambda w^s \hat{s} \cdot \hat{\lambda}),$$

(4.29)

where $I_B$ and $I_T$ are positive coefficients given in (4A.8) which capture redistributive effects. Substituting (4.25) and $\hat{H} = -\sigma \hat{T}$ into (4.28) yields the aggregate welfare effect,

$$\hat{V} = N \hat{V}_H + \hat{V}_L = -\left(\frac{\Gamma}{1 - \Gamma T \sigma - \sigma_{ET} \Gamma}\right) \cdot Y_H \hat{T}
+ \left(\rho \chi (1 - e) - \sigma_{EB} \Gamma\right) \cdot w \hat{b} - \left(s^0 \lambda w^s \hat{s} - \Gamma \sigma_{EB} \cdot eW\right) \cdot \hat{\lambda}.$$  

(4.30)

Lower transport costs facilitate outsourcing of unskilled tasks. This trend benefits skilled and harms unskilled workers. Noting $\hat{V}_L = \hat{V} - N \hat{V}_H$, the results in (4.29) and (4.30) give

$$N \hat{V}_H = -(I_\lambda eW + s^0 \lambda w^s \hat{s}) \cdot \hat{\lambda} > 0, \quad \hat{V}_L = (I_\lambda eW + \Gamma \sigma_{EB} eW) \cdot \hat{\lambda} < 0.$$  

(4.31)

Assuming labor market efficiency and starting from an untaxed equilibrium, globalization ($\hat{\lambda} < 0$) yields efficiency gains of $\hat{V} = -s^0 \lambda w^s \hat{s} \cdot \hat{\lambda}$. The gains from trade are reduced if a high participation tax and excessive unemployment ($\gamma > \eta$) result in a high distortion $\Gamma$. Given aggregate gains but an uneven distribution as in (4.31), is it possible to design a Pareto improving welfare policy? We suggest: (i) keep benefits constant to protect income of the unemployed; and (ii) implement a redistribution policy $\hat{T} > 0 > \hat{\tau}$ at a scale that prevents rising unemployment and falling disposable income of the unskilled. The tax cut (or wage subsidy) reduces the participation tax and offsets the negative employment effects of globalization. By (4A.5), the change in disposable income is proportional to the employment effect, i.e. $\hat{\tau} = 0$ implies $\hat{w} - \hat{r} = 0$. If neither incomes $w - \tau$ and $b$ nor employment $e$ change, welfare of the unskilled remains constant. From (4.25), we find a redistribution policy such that employment remains constant,

$$\hat{b} = 0, \quad Y_H \hat{T} = -\frac{L_\lambda/L_W}{1 - \Gamma T \sigma} eW \cdot \hat{\lambda} \quad \Rightarrow \quad \hat{V}_L = 0.$$  

(4.32)

In fully compensating unskilled workers, this redistribution policy is Pareto improving if it allows skilled households to keep part of the efficiency gain. Noting
the cost shares \( \frac{sx}{sx^o} = \frac{eW}{e\lambda W^T} \), and substituting (4.32) into (4.30) yields\(^{13}\)

\[
N\hat{V}_H = \hat{V} = -\left[ 1 - \frac{T}{1-T}\sigma \cdot \frac{L_\lambda sx}{L_W s^o x^o} \right] s^o \lambda W^T \cdot \hat{\lambda}.
\] (4.33)

When insurance is not cross-subsidized by the skilled \((T = 0)\), the redistribution policy allows all groups to share in the gains from trade and makes globalization Pareto improving. By continuity, choosing a policy slightly larger than in (4.32) boosts welfare of the unskilled by reducing the unemployment rate and raising disposable income of employed workers. If, however, the government is already redistributing substantially before globalization sets in, a high tax rate \(T\) on skilled households creates an excess burden which makes redistribution more costly and reduces the chances for a Pareto improvement.

### 4.4.3. Optimal Welfare Policy

A social welfare function \( \Lambda = NV_H + \xi V_L \) captures policy objectives where \( \xi \geq 1 \) reflects the concern for unskilled workers. An optimal redistribution policy requires

\[
d\Lambda/dT = u_H'N\hat{V}_H/dT + \xi u_L'\hat{V}_L/dT = 0,
\]

where \( \hat{V}_L = \hat{V} - N\hat{V}_H \). Substituting (4.29) and (4.30) yields

\[
\frac{\xi u_L' - u_H'}{\xi u_L'} \cdot IT = \frac{T}{1-T} \cdot \sigma - \Gamma \cdot \sigma_{E,T}.
\] (4.34)

The left-hand side reflects the gains from distribution when an amount \( I_T \) is redistributed from the rich with low marginal utility to unskilled workers with high marginal utility of income. The right-hand side expresses the excess burden. The difference to the standard tax literature is low-skilled unemployment and the contrast between intensive and extensive labor supply. Raising \( T \) creates an excess burden \( \frac{T}{1-T} \cdot \sigma \) due to intensive supply decisions of the skilled. In using revenue to cut the tax \( \tau \) of unskilled workers, or even pay a wage subsidy to them, the government boosts net of tax wages \( w - \tau \). The policy also lowers gross wages \( w \) which induces job creation and employment. It thus reduces the excess burden from the employment distortion of unskilled workers by \( \sigma_{E,T} \Gamma \), as measured by the participation tax rate \( \tau^* \) which is part of \( \Gamma \).

\(^{13}\)The technology in (4.4) implies \( x/x^o = (\omega^o/\omega)^{1/\delta-1} \). The cost advantage from outsourcing makes these firms larger, \( x < x^o \). With constant cost shares, labor demand coefficients in (4.22) are \( L_\lambda = \mu_a x^o \) and \( L_W = 1 + \frac{a_b}{1-\delta} + \mu_a x^o \). Using \( \pi^j = (1-\delta)x^j \) and \( \mu = \frac{a\sigma_q}{\pi^{qj}} \), we have \( L_W - L_\lambda = 1 + (1-\delta) \cdot \frac{a\sigma_q}{\pi^{qj}} \cdot \frac{a_b}{1-\delta} > 1 \), since \( \sigma_q(q) < s(q) \), so that \( \frac{L_\lambda}{L_W} < \frac{L_\lambda}{L_W} \cdot \frac{1}{\pi^{qj}} < 1 \). The larger is the importance of outsourcing \( (s^o x^o > sx) \), the more likely a reduction in transport cost raises aggregate welfare.
The condition for optimal insurance follows by the same steps as before,

\[(1 - e) \chi \cdot \rho + \frac{\xi u'_E - u'_H}{\xi u'_E} \cdot I_B = \Gamma \cdot \sigma_{E,B}. \tag{4.35}\]

To provide insurance to risk averse workers, the government raises taxes (contributions) to pay higher benefits, thereby shifting income from the good to the bad state. The first term reflects the gains from insurance when private UI markets are missing. In addition, the distributive term \(I_B\) raises welfare of low-skilled workers at the expense of high-skilled workers since UI benefits lead to higher wages and lower profits. The excess burden on the right-hand side reflects the participation tax \(\tau^*\) that arises when agents switch from employment into joblessness. Starting from small values, the excess burden is zero (in the absence of search distortions when \(\eta = \gamma\)) while the welfare gains from insurance and redistribution are strictly positive to the first order. Eventually, however, the progressively increasing excess burden limits the optimal size of the insurance program.

How do lower transport costs, leading to more outsourcing, affect optimal welfare policies? By (4.25), this shock reduces the employment rate and exposes unskilled workers to a larger income risk. By (4.31), it also contributes to more inequality, \(\hat{V}_H > 0 > \hat{V}_L\). The trend to outsourcing thus emphasizes the need for social insurance and redistribution. We conclude that the optimal response to globalization is to expand the role of the welfare state. Since redistributive taxation favors the employed unskilled population, it reduces the participation tax \(\tau^*\) and actually makes social insurance less damaging.

4.5. Conclusion

The trend to outsourcing of labor intensive components puts pressure on the welfare states of advanced economies. Based on a model of outsourcing and involuntary unemployment, we have shown how integration, by lowering transport costs of intermediate imports, facilitates outsourcing and impairs employment prospects and wages of unskilled workers while at the same time raising profits of top income earners. The resulting inequality and the increased income risk of unskilled workers seemingly emphasize the basic functions of the welfare state, redistribution and social insurance.

The need for an extended welfare state in the presence of globalization pressure...
arises even if the welfare state itself creates part of the problem that it is designed to solve. Offering higher replacement incomes for more insurance boosts wages and causes higher unemployment. By inducing even more outsourcing than would otherwise obtain, the impact of social insurance on unemployment of low-skilled workers is reinforced. These detrimental effects show up as part of the efficiency costs arising from welfare policies. However, expanding a linear income tax to redistribute more heavily from skilled to unskilled households might involve a smaller efficiency cost than is commonly perceived. Since the income tax redistributes only to households earning an active wage income, it cuts the high participation tax on unskilled workers and widens the income gap between work and joblessness. It thereby acts as a wage subsidy which is often deemed to become more important in advanced welfare states when the integration of the world economy accelerates. In our model, the redistribution in favor of low-skilled workers raises net wages while, at the same time, gross wages fall. It thereby initiates job creation and reduces unemployment among low-skilled workers. Since lower wage costs add to profits of integrated firms, the policy also helps to stem the tide towards outsourcing.
Appendix

A1 Wage Bargaining: The wage impact follows from bargaining, see (4.7). Approximate marginal utility by a Taylor expansion. Use \( u'_E = u'(w - \tau) \) and \( u'_B = u'(b + z) \) as a short-hand where lower indices \( E \) and \( B \) refer to the states of ‘Employment’ and ‘on Benefits’. Using \( \rho \equiv -cu''/u' \) as well yields

\[
u'_B \approx u'_E + u''_E \cdot (b + z - w + \tau) = u'_E \cdot (1 + \rho \chi), \quad \chi \equiv \frac{w - \tau - b - z}{w - \tau}.
\] (4A.1)

Given \( u_E - u_B \approx u'_E \cdot (w - \tau - b - z) \), we find \( d \frac{u_E - u_B}{u'_E} = (1 + \rho \chi) (dw - d\tau - db) \). Substitute job creation \( F_I - w = \kappa/m \) into (4.7) and use \( \eta \equiv -\theta m'/m \) and the approximations above. Expressing the change in taxes and benefits relative to the wage yields

\[
(1 + \rho \chi) w [\hat{w} - \hat{\tau} - \hat{b}] = \frac{\nu}{1 - \rho \chi} \eta \hat{\theta}.\]

Substituting again the wage bargaining condition on the right hand side and using \( u_E - u_B \approx u'_E \cdot (w - \tau - b - z) \) and \( \hat{\varepsilon} = (1 - \eta) \hat{\theta} \) finally yields (4.16).

A2 Wages and Labor Costs: Further analysis requires the general equilibrium impact on wages. Compare, separately for each shock, the coefficients in (4.25) to relate the equilibrium tax rate to the employment rate,

\[
T : \hat{\tau} = -\nabla \cdot \hat{e}, \quad b : \hat{\tau} = -[\tau^* + (1 - e) / \sigma_{EB}] \cdot \hat{e}, \quad \lambda : \hat{\tau} = -\tau^* \cdot \hat{e}.
\] (4A.2)

Consider the wage impact, \( \hat{w} = \hat{\tau} + \hat{b} + \frac{1 - \tau^* - z/w}{1 + \rho \chi} \frac{\eta}{1 - \eta} \hat{e} \), and use (4.2). Also use \( \hat{b} = - (e / \sigma_{EB}) \hat{\varepsilon} \) when evaluating the effect of unemployment insurance benefits. Noting \( \nabla \equiv \frac{W}{wL_w} + \frac{\eta}{1 - \eta} \psi_e \) and \( \psi_e \equiv \frac{1 - \tau^* - z/w}{1 + \rho \chi} + \frac{k/m}{w} \), the equilibrium relation between wages and employment is

\[
T : \hat{w} = -\left[ \frac{W}{wL_w} + \frac{\eta}{1 - \eta} \frac{k/m}{w} \right] \cdot \hat{e},
\[
b : \hat{w} = -\left[ \frac{W}{wL_w} + \frac{\eta}{1 - \eta} \frac{k/m}{w} \right] \cdot \hat{e},
\[
\lambda : \hat{w} = \left[ \frac{1 - \tau^* - z/w}{1 + \rho \chi} \frac{\eta}{1 - \eta} - \tau^* \right] \cdot \hat{e}.
\] (4A.3)

Higher transport costs boost employment which is expected to raise wages in (4A.3). The opposite case is, in principle, possible since higher employment reduces benefit spending and raises tax revenue so that \( \tau \) can be cut which tends to allow for a lower wage. This would be a rather pathological case that should be excluded on empirical grounds. Assuming \( \eta \) large (1 - \( \eta \) small) magnifies the direct effect of employment on the wage and makes it more likely to dominate.
the countervailing effect of the induced tax reduction. The following condition guarantees that a higher transport cost affects employment and wage in the same direction,

$$\frac{\eta}{1-\eta} > \frac{(1+\rho \chi) \tau^*}{1-\tau^*-z/w}. \quad (4A.4)$$

Obviously, this condition is fulfilled if the government sector is small ($\tau^* \to 0$). Henceforth, it is assumed to be fulfilled for positive taxes as well. Evaluating welfare changes requires the change in disposable wage income. Combining (4A.2) and (4A.3) yields

$$T : \hat{\bar{w}} - \hat{\bar{\tau}} = \frac{1-\tau^*-z/w}{1+\rho x} \frac{\eta}{1-\eta} \hat{\bar{\epsilon}}, \quad b : \hat{\bar{w}} - \hat{\bar{\tau}} = -\left[ \frac{W}{wLw} + \frac{\eta}{1-\eta} \frac{\kappa/m}{w} - \tau^* - \frac{1+e}{\sigma_{EB}} \right] \hat{\bar{\epsilon}}, \quad \lambda : \hat{\bar{w}} - \hat{\bar{\tau}} = \frac{1-\tau^*-z/w}{1+\rho x} \frac{\eta}{1-\eta} \hat{\bar{\epsilon}}. \quad (4A.5)$$

Finally, unit labor costs in (4.17), $\hat{\bar{W}} = \frac{\psi_e \cdot \eta}{1-\eta} \hat{\bar{\epsilon}} + \hat{\bar{b}}$, can similarly be related to employment. Using again $\hat{\bar{b}} = -\left( e/\sigma_{EB} \right) \hat{\bar{\epsilon}}$ and (4A.2) gives

$$T : \hat{\bar{W}} = -\frac{1}{Lw} \hat{\bar{\epsilon}}, \quad b : \hat{\bar{W}} = -\frac{1}{Lw} \hat{\bar{\epsilon}}, \quad \lambda : \hat{\bar{W}} = \frac{w}{W} \left[ \frac{\eta}{1-\eta} \psi_e - \tau^* \right] \hat{\bar{\epsilon}}. \quad (4A.6)$$

If condition (4A.4) holds, higher transport costs boost wages. The impact on gross wage costs $W$ is positive a fortiori if (4A.4) is satisfied (use $\psi_e$). Note that (4A.4) is also sufficient for stability, $\nabla = \frac{W}{wLw} + \frac{\eta}{1-\eta} \psi_e > \tau^*$.

A3 Profit Income: Finally, consider profits $\Pi = \bar{\pi} N$. Since $ds^o = -ds$ and $ds = -qds^f$, profits in (4.12) change by $d\Pi = s\bar{\pi} \hat{\bar{\epsilon}} + s^o \pi^o \hat{\bar{\epsilon}} + [(\pi^o - \pi) q - f^o] ds^f$. The square bracket is zero by choice of organizational form. Substitute (4.18-4.19) and note $\pi = (1-\delta) x$, $Lw = \alpha \delta x$ and $e = sl$,

$$d\Pi = -eW \cdot \hat{\bar{W}} - s^o \bar{\lambda} \bar{w}^s \cdot \hat{\bar{\lambda}}. \quad (4A.7)$$

Since $\hat{\bar{\lambda}} > 0$ implies $\hat{\bar{\epsilon}} > 0$ and by (4A.6) also $\hat{\bar{W}} > 0$, profits unambiguously rise when $\hat{\bar{\lambda}} < 0$ in the wake of globalization.

A4 Welfare Calculations: To get the welfare changes in their final form, substitute (4A.3) and (4.25) into (4.26). Do this separately for the variables $T, b, \lambda$, using (4A.3) in each step, and add up to finally obtain equation (4.29), where the
coefficients are defined as

\[ I_T \equiv 1 - \frac{W}{\sigma_{ET}}, \quad I_B \equiv \frac{W}{\sigma_{EB}}, \quad I_\lambda \equiv \left[ \frac{\eta}{1 - \eta} \psi_e - \tau^* \right] \sigma_{E\lambda}. \quad (4A.8) \]

Upon substituting terms, the first coefficient becomes

\[ I_T = \left( \frac{\eta}{1 - \eta} \psi_e - \tau^* + \frac{T}{1 - T} \frac{W}{\sigma_{WB}} \right) \sigma_{EB} > 0. \quad (4A.9) \]

The assumption (4A.4) used to sign (4A.3) is sufficient for \( I_\lambda > 0 \) and, a fortiori, \( I_T > 0 \).
Separate Appendix

Output Market Equilibrium

Adding the income of the high-skilled in (4.1) to average income $c_L \equiv (w - \tau)e + b(1 - e)$ of the low-skilled and imposing the fiscal budget (4.14) yields national income (GNP)

$$c_L + c_H N = Y \equiv ew + rHN + \Pi.$$  \hfill (4S.1)

GNP thus consists of earnings $rHN$ and profits $\Pi$ of high-skilled and wages $we$ of unskilled workers.

Walras’ Law implies that the goods market must clear when resource and budget constraints are fulfilled. Substitute (4.12), (4.5) and (4.8) into (4S.1)

$$s^o \lambda w^s f^o = (X + X^r - C) + (e - sI)w, \quad X \equiv sx + s^o x^o,$$  \hfill (4S.2)

$$C \equiv c_L + c_H N + \kappa sk + s^f f^o, \quad X^r \equiv r \cdot (HN - sh - s^o h^o).$$

Demand stems from consumer demand, and from business spending on search costs and fixed costs of outsourcing. The standard sector adds output $X^r$, depending on labor supply $HN$ of skilled workers in excess of the skill requirements in innovative production. Labor market clearing implies that the North runs a trade surplus $X + X^r - C$ to pay for imports of low-tech components. Their value corresponds to wage costs $s^o \lambda w^s f^o$ in the South when free entry squeezes subcontracting profits to zero.

The South is endowed with unskilled labor and is specialized in standard production with a low, fixed productivity $w^s$, and in manufacturing low-tech inputs for the North. Per capita utility is equal to consumption, $V^s = u(w^s)$. Given a fixed endowment $L^s$, demand and welfare are $C^s = w^s L^s$ and $V^s = u(w^s) L^s$, respectively. Market clearing in the South is

$$X^s - C^s = -s^o \lambda w^s f^o, \quad X^s \equiv w^s (L^s - s^o \lambda f^o).$$  \hfill (4S.3)

The South runs a trade deficit in goods financed by a trade surplus in low-tech intermediate inputs (corresponding to international factor payments). Adding up (4S.2) and (4S.3) yields market clearing for the world goods market, $C + C^s = X + X^r + X^s$. 

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Outsourcing and Unemployment in Europe

This section discusses some empirical evidence on outsourcing and labor market performance of low-skilled workers. We focus on high-wage European countries. Outsourcing to foreign countries has increased significantly over the last decades. In particular, trade in intermediate inputs in the manufacturing sector has gained in importance, as for instance documented by Campa and Goldberg (1997) for the period from the mid 1970s to the mid 1990s. In 1995, the share of these inputs relative to total output was between 6-12% in many OECD countries, as illustrated in Figure 4.2. There is, however, quite a strong dispersion in outsourcing rates. Countries with a larger domestic market, such as the US, have typically lower rates than smaller countries. A common fear with regard to outsourcing is that it substitutes for domestic jobs, especially among the low-skilled. The welfare consequences might be severe since labor market prospects of low-skilled workers are typically worse compared to other employment categories. Indeed, in 1995, the unemployment rates among the low-skilled exceeded 10% in many European countries, see Figure 4.2, with a tendency to higher unemployment rates in countries with higher outsourcing.

Negative effects for low-skilled workers are expected primarily from outsourcing
to low-wage countries. This category has become relatively more important in recent years. Falk and Wolfmayr (2008) report that in the period 1995-2000, imports of intermediates from low-wage economies grew at an average of 9% per year in the five EU countries Austria, Finland, Germany, Italy and the Netherlands. Furthermore, foreign direct investment in non-OECD countries is rising significantly and partly reflects growing competition from low-wage countries as well. In several European countries, cumulative outward FDI flows grew beyond 4% of GDP over the period 2000-2005, and in Switzerland it even amounted to 16% of GDP (see Figure 4.3). Although in recent years, and especially in the 1990s, policymakers have introduced substantial labor market reforms to reduce unemployment rates among the low-skilled (see for instance Andersen and Svarer, 2007, for the particularly successful case of Denmark), unemployment rates have again accelerated in several European economies in the period 2000-2005.

Many countries have implemented labor market and social security reforms in recent years, partly in response to growing globalization pressure. Cross-country illustrations like Figures 4.2 and 4.3 tend to mix up the impact of outsourcing with these other influences. To get the isolated effect of outsourcing, one has to control for the differential impact of labor market institutions, social security provisions and other factors that influence unemployment independently of outsourcing.
This is explicitly discussed in Geishecker and Görg (2008, p.250) in their study of the effects of outsourcing on the wages of low-skilled workers, and in the study of Geishecker (2008, p.9) on the impact of outsourcing on employment risk. Other studies that derive the effects of outsourcing on labor market performance of low-skilled workers include Feenstra and Hanson (1996) for the US, Anderton and Brenton (1999) and Hijzen, Görg, and Hine (2005) for the UK, Strauss-Kahn (2003) for France, Ekholm and Hakkala (2006) for Sweden and Falk and Wolfmayr (2008) for the five EU countries mentioned above. These studies consistently find negative impacts of outsourcing on the demand for low-skilled labor. To the extent that the unemployment risk for this group is aggravated, the welfare state and in particular the unemployment insurance system become more important to avoid large consumption losses. As Figure 4.4 shows, replacement incomes are typically very high in Europe, in many countries exceeding 70% of the previous wage. However, as we elaborate in the paper, increasing workers’ reservation wages by making unemployment insurance more generous itself leads to more outsourcing and higher unemployment.
Chapter 5

Optimal Size and Intensity of Job Search Assistance Programs

Evelyn Ribi*

This chapter derives the welfare optimal size and intensity of job search assistance programs in a general equilibrium model where the labor market is affected by search frictions. Both instruments have a priori ambiguous fiscal implications: their direct employment stimulating effects broaden the base of the labor income tax and increase revenues, while also incurring direct costs. At optimal levels, the policy instruments trade off the positive effects on the participants against a marginal increase in taxes, which distorts employment decisions and potentially labor market tightness. Further, the introduction of a job search assistance program is more likely to raise welfare if it is highly effective at improving participants’ job search skills, direct program costs are low and if the general level of taxation in the economy and thus the labor market participation tax are high.

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5.1. Introduction

Over the last decades, active labor market programs have been part of most industrialized countries’ policies to bring the unemployed back into work. A considerable share of the unemployed are assigned to participate in these programs, and total public expenditures amount to more than 1% of GDP in some OECD countries (OECD, 2006). The most commonly used policies are job search assistance programs, which shall improve the job search skills of the unemployed rather than their productivity in a given occupation. Examples of such measures include training of how to apply for a job, practicing job interviews, but also counselling and direct referrals to potentially suitable jobs by the public employment service. These activities typically require no long-term instruction and are therefore relatively cheap compared to other activation measures. However, due to their high prevalence, their costs for taxpayers nevertheless reach up to about 0.3% of GDP in several OECD countries (OECD, 2006).

Microeconometric evaluations of existing programs indicate that, in contrast to other activation measures, job search assistance appears to be effective for a broad range of participants (see the surveys in Fay, 1996; Heckman, LaLonde, and Smith, 1999; Martin and Grubb, 2001; Kluve and Schmidt, 2002). This means that participants have a higher transition rate to employment than if they had not attended the program. However, due to their considerable size, job search assistance programs must be expected to affect also the labour market situation of non-participants. These effects are captured in macroeconometric evaluation studies, which typically analyze the impact of activation measures on the aggregate unemployment or employment rates. Although the evidence is still scarce, most existing studies suggest that the macroeconomic implications are often significant (see for example Calmfors and Skedinger, 1995; Blundell, Costa Dias, Meghir, and Van Reenen, 2004; Boone and Van Ours, 2004, and the references therein).

A number of theoretical papers more systematically characterize how job search assistance programs influence the macroeconomic equilibrium. Calmfors and Lang (1995) study the implications on wages and employment when the program is targeted at the long-term versus the short-term unemployed. Distinguishing between high- and low-skilled workers, Van der Linden (2005) analyzes the effects of a program expansion among the low-skilled by step-wise endogenization of variables. Both studies stress that general equilibrium reactions substantially influence a program’s implications on aggregate employment. Repercussions can
even be so severe that the employment rate falls in consequence of a job search assistance program. This possible outcome is also explicitly taken up by Saint-Paul (1998), who identifies the conditions under which unskilled workers will vote for a labor market program that actually raises unemployment. In a nutshell, by characterizing the implications of job search assistance programs in a general equilibrium setting, these papers highlight the different channels through which workers’ employment prospects are affected by these policies.

However, when it comes to judging the overall effects and desirability of a policy, the evaluation criterion that should ultimately be considered is social welfare rather than employment. The above studies provide only to a reduced extent information about this measure: Saint-Paul (1998) discusses utility effects for employed low-skilled workers, but does not capture the welfare consequences for other groups in the economy. Van der Linden (2005), on the other hand, shows a simulation of aggregate welfare as a function of program size, but does not, in his theoretical analysis, integrate the different effects to a social welfare measure. This issue is taken up in this paper.

The aim of this paper is to characterize the effects of job search assistance programs on social welfare and to perform a normative analysis of such a policy. We concentrate on the two most important characteristics: the size of a program, i.e. the number of jobseekers attending, and its intensity, which is a measure of the total services provided to each participant. The optimality criteria for both characteristics are derived in a general equilibrium framework where the labor market is affected by search frictions and wages are bargained between firms and workers. Workers are ex ante homogeneous, and assignment to the job search assistance program is undertaken by the government. We find that both instruments should optimally trade off their direct beneficial impact on program participants (or marginal participants in the case of program size) against the fiscal implications for taxpayers and ensuing distortions of employment and labor market tightness. The fiscal implications consist of two parts: first, program enlargement or intensification of course has direct costs, as more instruction and counselling have to be financed. Secondly, the direct employment enhancing effect on participants also changes the government budget. On the one hand, it widens the base of the labor income tax, thus providing more revenues. On the other hand, it cuts down to the same extent the number of individuals living on unemployment insurance compensation and thus saves benefit expenditures. This sum of taxes and benefits is generally denoted as the participation tax of the unemployment
insurance system and can reach considerable levels, especially in European countries with traditionally generous welfare states (see Immervoll, Kleven, Kreiner, and Saez, 2007). Our analysis shows that at the optimal levels of program size and intensity, their net fiscal impact is negative, requiring a marginal increase in the labor income tax. This not only reduces consumption possibilities of the taxpayers, but also distorts labor market participation. Depending on the relationship between workers’ bargaining power and the elasticity of the matching function with respect to jobseekers, the reaction of labor market tightness provoked by a tax rise might also be distortionary.

Our analysis also provides insights on the question whether a job search assistance program should be introduced in the first place. Program introduction is more likely to improve social welfare if participation significantly increases a worker’s effectiveness in job search activity and if the costs incurred by the first participant are not too high. Further, we show that if the general level of labor income taxation in the economy is high, implying that the fiscal savings in the form of the participation tax compensate the direct program cost, program introduction is also more beneficial. This finding might explain why active labor market policies are especially prevalent in countries with large social welfare systems and high levels of taxation, like Belgium, Denmark, Finland, the Netherlands or Sweden.

Our paper connects to several strands of the literature. A few recent papers study the optimal sequence of different active and passive labor market policies for the unemployed (see Pavoni and Violante, 2007; Wunsch, 2007; Spinnewijn, 2008). However, by focusing on individual jobseekers only, these papers do not consider the feedback effects on other agents in the economy, which should be taken into account when designing potentially large programs. As discussed above, the general equilibrium studies of Calmfors and Lang (1995) and Van der Linden (2005) focus mainly on a positive analysis of program effects on employment and thus stop short of deducing normative implications. A notable exception, albeit focusing on a different measure of active labor market policy, is Fredriksson (1999), who studies the optimal number of participants in public employment programs.

The influence of the participation tax on both program introduction decisions and optimal program design also highlights the importance of interactions between different elements of active and passive labor market policies, which has already received some attention in the literature. For instance, in Keuschnigg and Ribi (2009) the participation tax of the unemployment insurance system is shown to play also a significant role in the determination of optimal wage subsidies (as

The paper proceeds as follows. Section 5.2 introduces the model, and Section 5.3 discusses the comparative static effects of changes in the government instruments. Section 5.4 then derives optimal program size and intensity, and Section 5.5 concludes. The Appendix provides some more technical calculations.

5.2. A Simple Model

The analytical framework is based on a one-period model of a labor market affected by frictions. This set-up provides a situation where individuals’ job search efforts are only partially successful and there might be a role for a policy that addresses this issue. To focus on the main mechanisms at work, the model is kept simple in other respects.

The economy contains a mass one of ex ante homogeneous workers. In the beginning, all individuals are unemployed and have to exert positive search effort to be able to find a job. Given their search effort, they can then with a certain probability secure a suitable job, paying a net wage $w - t$. Otherwise, individuals end up unemployed and receive unemployment insurance benefits $b$ from the state.

To enhance matching in the labor market and stimulate employment, the government runs an active labor market program that provides job search assistance to the unemployed. The assignment of unemployed workers to the program is undertaken by the government, and for the designated individuals participation is mandatory. This is also very common in practice, where it is mostly at the discretion of the public employment service to place the unemployed into different programs. The share of program participants in the whole population, i.e. the size of the program, is denoted by $\phi$. For participants, the labor market program leads to an increase in their search effectiveness. Given a level of search effort $s_p$, their

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1We assume that there are no privately run labor market programs in this economy, which is a common assumption in the theoretical literature. In reality, the policy discussion clearly centers on publicly funded programs, and many unemployed workers might also be cash constrained to attend programs for which they would have to pay themselves. Further, some measures of job search assistance programs also contain monitoring elements, and can therefore be provided only by the public authority.
actual search effectiveness then amounts to $\delta_{SP}$ with $\delta > 1$. The factor $\delta$ is thus interpreted as a measure of the intensity of the program. The two defining characteristics $\phi$ and $\delta$ of the job search assistance program are both policy instruments of the government.

The number of suitable job matches $M$ formed in the economy depends on the number of vacancies $V$ set up by firms and on the effective number of jobseekers

$$S = \phi \cdot \delta_{SP} + \left(1 - \phi\right) \cdot s_N,$$

where effective search intensities of the two groups (participants versus non-participants) are multiplied with the relative weight of the respective group in the population. In accordance with the literature, we assume the matching function to be increasing and linear homogeneous in the arguments $S$ and $V$, or specifically, $M(S, V) = m_0 S^\alpha V^{1-\alpha}$. In what follows, it will be convenient to use the concept of labor market tightness $\theta$, reflecting the ratio of vacancies to the effective number of jobseekers:

$$\theta \equiv \frac{V}{S}.$$

In this static model, the employment rate $e$ in the economy is given by the ratio of successful matches that are formed relative to initial jobseekers, who have mass one: $e = m_0 S^{\theta^{1-\alpha}}$. From the point of view of a single individual, the probability $p$ of finding a job depends on whether he has participated in the job search assistance program. If he has not taken part in the program, his search effectiveness $s_N$ implies a probability of finding a job of

$$p_N = \frac{s_N M}{S} = s_N m_0 \theta^{1-\alpha}.$$  

(5.2)

Analogously, a person who has participated in the program has an effective search intensity of $\delta_{SP}$, leading to a job finding probability of

$$p_P = \frac{\delta_{SP} M}{S} = \delta_{SP} m_0 \theta^{1-\alpha}.$$  

(5.3)

Job search probabilities for the two groups and the aggregate employment rate thus increase in labor market tightness. Finally, a firm can fill a vacancy with probability $q = m_0 \theta^{-\alpha}$, which is decreasing in market tightness.

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2The index $P$ stands for program participants, the index $N$ denotes non-participants.
5.2.1. Job Search Decision

Individuals determine their job search effort to maximize expected utility. Job search incurs effort costs $\varphi(s)$, which is an increasing and convex function of $s$. It is assumed that both groups of jobseekers have the same effort cost function. Individuals who have not participated in the labor market program know that they have a probability $p_N$ of finding a job. In this case, they earn a gross wage $w$, but have to pay a labor income tax of $t$. If they end up unemployed (with probability $1 - p_N$), they receive unemployment insurance benefits of $b$. Their indirect expected utility is thus

$$EU_N = \max_{s_N} p_N u(w - t) + (1 - p_N) u(b) - \varphi(s_N),$$

(5.4)

where $u$ is a standard concave utility function. Optimal job search effort $s_N$ is determined by the condition

$$m_0 \theta^{1-\alpha} \left[ u(w - t) - u(b) \right] = \varphi'(s_N).$$

(5.5)

The left-hand side shows the marginal benefit of increased search effort: as a higher search effort raises the probability of finding a job, see (5.2), it becomes more likely that the individual can move out of unemployment and thus realize the utility difference $u(w - t) - u(b)$. It is clear that to uphold positive search incentives, this utility difference must be positive. This will be ensured by wage bargaining. The right-hand side shows the marginal effort cost associated with higher search effort.

For a jobseeker who has participated in the job search assistance program, the probability of finding a job is given by $p_P$ in (5.3), and expected utility is

$$EU_P = \max_{s_P} p_P u(w - t) + (1 - p_P) u(b) - \varphi(s_P).$$

(5.6)

We thus assume that the time spent in the program does not directly affect a person’s effort cost per unit of job search activity. This seems reasonable given that job search assistance does not require a very high time input by participants. Therefore a lock-in effect cannot occur either in our model, which is often found to be important for more intensive program types like training (cf. Lechner, Miquel, and Wunsch, 2006). Optimal job search effort $s_P$ follows from the condition

$$\delta m_0 \theta^{1-\alpha} \left[ u(w - t) - u(b) \right] = \varphi'(s_P).$$

(5.7)
Due to program participation, the marginal increase in the job-finding probability is $\delta m_0 \theta^{1-\alpha}$, which is higher than in the case of a non-participant if the program is effective ($\delta > 1$). The convexity of the search cost function then implies that program participants exert higher search effort than non-participants. Comparing (5.2) and (5.3), it follows that the probability of finding a job is higher for participants for two reasons: first, they exert higher search effort, and second, their search effort is more effective due to the multiplier $\delta$. We can also show that despite higher effort costs, participants end up with higher expected utility than non-participants, $EU_P > EU_N$ (see Appendix). The labor market program thus creates inequality between participants and non-participants.

5.2.2. Firms

All firms in the economy produce the same numeraire good. Each firm can only create one vacancy, which costs $k$ units of the numeraire. With probability $q$, it then finds a suitable worker to fill the post and produce $y$ units of output, and pays the worker a gross wage of $w$. If it fails to find a worker, its output is zero. A firm’s expected profits are therefore $E(\pi) = q(y - w) - k$. With free entry, firms enter the economy until expected profits are driven down to zero:

$$\sigma(y - w) = k.$$  \hspace{1cm} (5.8)

The wage is determined by Nash bargaining. Once a successful worker-firm match has been created, both actors know that they can share a rent. Breaking up the relationship would leave both with their outside option, which is zero for the firm and $u(b)$ for the worker, as we have assumed one shot matching. With $\gamma \in (0,1)$ denoting the worker’s bargaining power, the wage is determined by $w = \arg\max [u(w - t) - u(b)] \gamma [y - w]^{1-\gamma}$, or implicitly by the first order condition

$$\gamma u'(w - t)[y - w] = (1 - \gamma)[u(w - t) - u(b)].$$  \hspace{1cm} (5.9)

5.2.3. Equilibrium

The labor market and the government’s budget constraint jointly determine the equilibrium in the economy. There are $V$ vacancies posted by all firms together, and workers’ search behavior implies an effective number of jobseekers $S$. Labor
market equilibrium requires that both labor supply and labor demand are equal to the number of matches formed with the given vacancies and jobseekers:

\[ e = M(S, V) = qV. \] (5.10)

Aggregate employment is given by the total mass of program participants and non-participants that were able to secure a suitable job, and is thus a weighted sum of the respective job-finding probabilities: \( e = \phi p_p + (1 - \phi)p_N. \)

The government has two categories of expenditures: first, it pays out unemployment insurance benefits to the unemployed, which requires outlays of \((1 - e)b.\) Second, it bears the cost of the job search assistance program. This cost is denoted by \(G(\delta, \phi)\) and increases both with program intensity and program size, \(G_{\delta} > 0\) and \(G_{\phi} > 0.\) The government’s sole source of revenues is the labor income tax, leading to income \(et.\) A balanced budget requires

\[ (1 - e)b + G(\delta, \phi) = et. \] (5.11)

The variables \(b, \phi\) and \(\delta\) are the government’s policy instruments. Via unemployment insurance benefits, it provides social insurance for those who are not successful on the job market. As the labor market is affected by frictions, investing in labor market programs increases employment probabilities of the share of participants \(\phi\) by raising their search effectiveness via \(\delta.\)

### 5.2.4. Market Clearing

Walras’ Law implies that the market for the numeraire good must clear when budget constraints are fulfilled and the labor market is in equilibrium, \(e = qV.\) Individuals spend all disposable income on the numeraire good, leading to private consumption \(C \equiv e(w - t) + (1 - e)b.\) Using (5.11) to eliminate the tax rate and the free entry condition (5.8) yields the GDP identity

\[ qyV = C + G + Vk. \]

Total production \(qyV\) of the numeraire good is thus used for private consumption \(C,\) public investment \(G\) in the labor market program, and for capital input \(Vk\) to create vacancies.
5.3. Policy Changes and Employment Effects

In this section, we analyze how changes in the size and intensity of the job search assistance program affect the employment probabilities of the two groups of workers and aggregate employment in the economy. To isolate these effects, we first derive the comparative statics of the model.

5.3.1. Comparative Statics

Starting out from an equilibrium in the economy, this section determines how changes in the government’s policy instruments $b$, $\phi$ and $\delta$ affect equilibrium values of the endogenous variables. Unless otherwise indicated, the hat notation designates changes in variables relative to their pre-change equilibrium values.

The gross wage $w$ of low-skilled workers is determined by the bargaining condition (5.9). In log-linearizing this equation, we apply the approximations $u_B \approx u_E - (w - t - b)u_E'$ and $u_B' \approx (1 + \rho \chi)u_E'$, where $\rho \equiv -c u''(c)/u'(c)$ is the coefficient of relative risk aversion of workers and $\chi \equiv \frac{w-t-b}{w-t}$ captures the relative income difference between the employed and the unemployed state. Indexed utilities stand for consumption utility in the employed ($u_E \equiv u(w - t)$) and the unemployed ($u_B \equiv u(b)$) states. The change in the wage is then given by

$$\hat{w} = \omega(\hat{b} + \hat{t}), \quad \omega \equiv \frac{(1 - \gamma)(1 + \rho \chi)}{1 + (1 - \gamma)\rho \chi}, \quad 0 < \omega < 1,$$

(5.12)

where $\hat{b} \equiv db/w$ and $\hat{t} \equiv dt/w$. A rise in the unemployment benefit $b$ improves the outside option of workers. For a given wage level, this reduces the income difference between the two employment states. Via wage bargaining, a part of this reduction is shifted to firms, leading to a higher gross wage. Analogously, an increase in the tax $t$ reduces the net wage and is also partially shifted to firms. Log-linearizing the optimality condition for job search effort (5.5) (use again the approximations for $u_B$ and $u_B'$) yields the change in search effort of non-participants,

$$\hat{s}_N = \sigma (1 - \alpha) \hat{\theta} + \frac{\sigma}{1 - \ell} \left[ \hat{w} - \hat{t} - (1 + \rho \chi)\hat{b} \right],$$

(5.13)

with $\sigma \equiv \phi'(s)/\phi''(s)s > 0$ determining the magnitude of the response of search effort to a change in the marginal return to searching. The term $t^* \equiv \frac{t+b}{w}$ captures the labor market participation tax. This consists of the total fiscal transfers a
worker has to give up when moving from joblessness into employment, i.e. the
unemployment insurance compensation he loses plus the tax he additionally has
to pay when earning a wage. Equation (5.13) shows that as a higher labor market
tightness and a greater income difference in the two employment states (expression
in brackets) increase the return to job search, they stimulate the search effort of
non-participants. For program participants, the change in job search effort follows
from differentiating (5.7):

\[
\hat{s}_p = \sigma \hat{\delta} + \sigma (1 - \alpha) \hat{\theta} + \frac{\sigma}{1 - \hat{t}^*} \left[ \hat{w} - \hat{t} - (1 + \rho \chi) \hat{b} \right].
\]

(5.14)

In addition to the general equilibrium effects that also affect the job search behavior
of non-participants, workers who attend the active labor market program also raise
their search effort in a direct reaction to an increase in program intensity \( \delta \). As a
higher \( \delta \) makes a given level of job search more effective, thus translating into a
higher employment probability, it raises the return to searching and consequently
stimulates this activity. The effective number of jobseekers \( S \), defined in (5.1),
finally changes by

\[
S \hat{S} = (\delta s_p - s_N) (1 - \phi) \hat{\delta} + \phi s_p \delta \hat{\delta} + \phi \delta s_p s_p + (1 - \phi) s_N s_N,
\]

(5.15)

where the relative change in program size is defined as \( \hat{\phi} = d\phi/(1 - \phi) \). Increases
in program size and intensity directly raise \( S \) as they expand the number of
workers who can benefit from the program and make search effort more effective,
respectively. Indirect effects come about because of the changes in search efforts
within the two groups, as indicated in (5.13) and (5.14).

The number of firms in the economy and thus, for a given \( S \), also labor market
tightness are determined by the zero profit condition (5.8). Using the matching
function to express the probability of filling a vacancy, \( q = m_0 \theta^{-\alpha} \), implies

\[
\hat{\theta} = - \frac{w \hat{w}}{\alpha (y - w)}.
\]

(5.16)

A higher gross wage reduces the firms’ rent of a successful job match. To rebalance
the zero profit condition, the probability of filling a vacancy must therefore rise,
implying a reduction in labor market tightness.

By the definition of the matching function, an equilibrium on the labor market is
ensured, and changes in employment, \( \hat{e} = \hat{S} + (1 - \alpha) \hat{\theta} \), equate changes in labor
demand, \( \hat{q} + \hat{V} \). Last, the tax rate \( t \) is endogenously determined to balance the
government budget constraint (5.11), and differentiating yields

\[ \dot{t} = \frac{1 - e}{e} \dot{b} - t^* \dot{e} + \frac{G_\delta \delta}{ew} \dot{\delta} + \frac{G_\phi (1 - \phi)}{ew} \dot{\phi}. \]  

(5.17)

For a given unemployment rate, higher benefit payments \( b \) raise expenditures, and must be financed by higher taxes on labor income. Similarly, when increased size or intensity make the labor market program more costly, this must also be covered by higher taxes. A higher employment rate, on the other hand, reduces the number of benefit recipients and, at the same time, increases the number of taxpayers. Thus, for each additionally employed, revenues in proportion to the participation tax \( t^* \) are added to the state’s budget, allowing for a corresponding reduction in the labor income tax. Inserting for the change in employment, and using equations (5.12)-(5.16) lets us write the change in the tax as a function of changes in the policy parameters only:

\[ \dot{t} = \left( \frac{1 - e}{e} + t^* (\sigma + 1) \frac{(1 - \alpha) \omega \omega}{\alpha (y - w)} + \frac{t^* \sigma}{1 - t^*} (1 + \rho \chi - \omega) \right) \frac{\dot{b}}{\Psi} \]

\[ + \left( \frac{G_\phi}{ew} - t^* \frac{\delta s_p - s_N}{S} \right) \frac{(1 - \phi) \dot{\phi}}{\Psi} + \left( \frac{G_\delta}{ew} - t^* (1 + \sigma) \frac{\phi s_p}{S} \right) \frac{\dot{\delta}}{\Psi}, \]

\[ \Psi \equiv 1 - t^* (\sigma + 1) \frac{(1 - \alpha) \omega \omega}{\alpha (y - w)} - \frac{t^* \sigma}{1 - t^*} (1 - \omega). \]

For stability reasons, it is required that \( \Psi > 0 \). This term captures the behavioral responses of jobseekers and firms to an increase in the tax that lead to a reduction in employment. The ensuing erosion of the tax base implies that the tax must be raised by a greater amount to generate a certain level of revenues than would be required in the absence of any endogenous behavioral response.

An increase in the unemployment insurance benefit \( b \) has an unambiguously positive effect on the tax \( t \). An increase in the size \( \phi \) of the job search assistance program has two counteracting effects on the tax: on the one hand, program expansion has a direct marginal cost \( G_\phi > 0 \), which must be covered by higher taxes. On the other hand, as more workers benefit from higher search effectiveness, substituting \( \delta s_p \) for \( s_N \) in their probability to find a job, this has a direct positive impact on the employment rate. As discussed above, this leads to fiscal savings in proportion to the participation tax \( t^* \), which implies the labor income tax can be reduced. The total effect of a change in \( \phi \) on \( t \) is ambiguous.

A rise in program intensity \( \delta \) has analogous effects on the tax as a change in \( \phi \). The
increase in program costs $G_\delta > 0$ puts an additional burden on the public budget. A more intensive program, however, raises search effectiveness of participants both directly and indirectly by stimulating search effort. As a result, program participants face a higher probability of finding a suitable job, which boosts overall employment. This has again the positive implications for the fiscal budget discussed above. The aggregate effect of an increase in $\delta$ on the public finances and thus on the tax rate that must balance the budget is again ambiguous.

5.3.2. Employment Effects of Changes in Size and Intensity

Having fully determined the comparative statics of the model, we can now isolate the effects of changes in program size and intensity on search behavior and employment probabilities for the different groups. This lets us relate our results more clearly to existing studies of macroeconomic effects of job search assistance programs, in particular to Van der Linden (2005). In this section, we keep the level of unemployment insurance benefits constant. For ease of exposition, we abbreviate the effects on the tax in (5.18) by

$$\hat{t} = \lambda \cdot \frac{\delta}{\Psi} + \xi \cdot \frac{(1 - \phi)\hat{\phi}}{\Psi},$$

(5.19)

$$\lambda \equiv \frac{G_\delta}{ew} - t^* (1 + \sigma) \frac{\phi s_P}{S}, \quad \xi \equiv \frac{G_\phi}{ew} - t^* \delta s_P - s_N.$$

The term $\lambda$ thus captures the net tax effect of an increase in program intensity $\delta$ we discussed just above, while $\xi$ summarizes the net tax effect of a rise in program size $\phi$. Inserting this and equations (5.16) and (5.12) into (5.14) shows that in reaction to changes in $\delta$ and $\phi$, program participants alter their search effort according to

$$\hat{s}_P = \sigma \delta - \psi_s \lambda \frac{\delta}{\Psi} - \psi_s \xi \frac{(1 - \phi)\hat{\phi}}{\Psi},$$

(5.20)

$$\psi_s \equiv \sigma (1 - \alpha) w \omega + \sigma \frac{1 - \omega}{1 - t^*} > 0.$$

Of course, the direct effect of a higher program intensity $\delta$ exerts the same influence on search effort as already identified above. The term $\psi_s$ summarizes the general equilibrium effects that feed back on participants’ job search efforts. They consist of an adjustment in labor market tightness, which directly influences matching probabilities, and a change in the consumption utility difference that can be gained when securing a job. Aggregate indirect effects of a change in $\delta$ are thus a negative
multiple of $\lambda$. As long as a rise in $\delta$ has a negative net impact on the tax $t$ ($\lambda < 0$), the equilibrium implications for search effort are also positive. However, direct and indirect effects become counteracting when $\lambda > 0$, and if the required tax increase is sufficiently high (implying $\lambda \frac{\psi_s \delta}{s} > \sigma$), a rise in program intensity might even reduce the job search effort of participants.

In the case of program size $\phi$, search effort of participants only changes in response to the equilibrium feedback of the implied change in the tax on labor market tightness and the consumption utility differential, which is in negative proportion to $\xi$. Thus, when additional jobseekers enter a program, search activities of those already attending might rise or fall, depending on the sign of $\xi$.

Differentiating (5.3), the change in participants’ probability to find a suitable job is given by $\hat{p}_P = \delta + \hat{s}_P + (1 - \alpha)\hat{\theta}$, or, upon inserting (5.20) and (5.16) (and using equations (5.12) and (5.19)),

$$\hat{p}_P = (\sigma + 1) \delta - \psi_p \lambda \frac{\delta \hat{\delta}}{\Psi} - \psi_p \xi \frac{(1 - \phi)\hat{\phi}}{\Psi},$$

$$\psi_p \equiv \psi_s + \frac{(1 - \alpha)\omega \omega}{\alpha(y - w)} > 0.$$  

As a higher program intensity directly increases search effectiveness and also search effort, the direct effect on the employment probability is positive. The indirect effects working on search effort (see (5.20)) are now complemented by the additional impact of a change in market tightness, which directly influences the matching probability. These aggregate indirect effects are summarized in $\psi_p$ and are again a negative multiple of $\lambda$, or, in the case of a change in program size, of $\xi$.

For workers not assigned to participate in the job search assistance program, there are no direct effects of changes in $\delta$ and $\phi$ on either search effort or the probability to find a job. The respective equilibrium adjustments are given by

$$\hat{s}_N = -\psi_s \lambda \frac{\delta \delta}{\Psi} - \psi_s \xi \frac{(1 - \phi)\hat{\phi}}{\Psi} \text{ and } \hat{p}_N = -\psi_p \lambda \frac{\delta \delta}{\Psi} - \psi_p \xi \frac{(1 - \phi)\hat{\phi}}{\Psi},$$

and are thus the same as the equilibrium feedback effects for program participants.

Finally, we can derive the impact on aggregate employment by inserting (5.15) and (5.16) into $\hat{e} = \hat{S} + (1 - \alpha)\hat{\theta}$ and using (5.19) and the changes in search efforts $\hat{s}_P$ and $\hat{s}_N$ from above:

$$\hat{e} = (1 + \sigma) \frac{\phi_s}{s} \delta + \psi_p \lambda \frac{\delta \delta}{\Psi} + \frac{\delta s_p - s_N}{s} (1 - \phi)\hat{\phi} - \psi_p \xi \frac{(1 - \phi)\hat{\phi}}{\Psi}.$$  

(5.22)
On the one hand, an increase in program intensity has a positive direct effect on employment within the group of participants. They benefit from higher effectiveness of their job search effort, and raise their effort in response. Both effects translate into a higher employment probability for this group. On the other hand, the fiscal consequences of a rise in $\delta$ and their implications for the equilibrium wage and labor market tightness affect all individuals in the same way, leading to an employment change that is proportional to $\lambda$. Aggregate employment effects might thus be positive as long as the fiscal consequences do not require too high an increase in the tax rate.

When the number of program participants is raised, this also has a positive direct effect on employment. As we have seen in Section 5.2.1, individuals who have attended the program always exert higher search effort than those who have not. And because search effort of participants is made even more effective by the multiplication with $\delta$, their probability of finding a job is higher than that of non-participants. Thus, increasing the share of the population entering the program directly increases the employment rate by the respective differential. The effects on the public budget and thus on the tax rate again lead to general equilibrium adjustments of the search efforts and market tightness, which affect all workers in the same way. Depending on whether the fiscal gains of program expansion exceed the fiscal costs or not, the indirect equilibrium effects might be positive or negative. When the necessary increase in the tax rate turns out to be too high, aggregate employment might even be reduced when more jobseekers enter the job search assistance program.

These results confirm the findings of Van der Linden (2005), who shows in simulations how the positive direct employment effects of an expansion of a job search assistance programs can be more than compensated when all general equilibrium implications are considered. Our discussion, however, provides further insights into the theoretical conditions that must be satisfied for such an outcome to occur, as it relates the change in employment fully to the fundamental changes in program characteristics $\phi$ and $\delta$.

5.4. Optimal Program Size and Intensity

Having seen how changes in the size and the intensity of a job search assistance program affect employment probabilities of both participants and non-participants, we now analyze how these instruments should be set optimally.
Social welfare $W$ is defined as aggregate welfare of all individuals, $W = \phi EU_P + (1 - \phi)EU_N$, and, because population size is normalized to one, corresponds to the expected utility of a person before program assignment has taken place. Differentiation of $W$ shows that social welfare is, on the one hand, affected by changes in the expected utility of the different groups of workers, and, on the other hand, by a changing composition of program participants versus non-participants in the population:

$$dW = \phi dEU_P + (1 - \phi)dEU_N + [EU_P - EU_N](1 - \phi)\hat{\phi}. \tag{5.23}$$

To derive the welfare effects and the optimality criteria for the program characteristics, it is first necessary to analyze how these instruments affect expected utility of the different groups, which we do in the next subsection. To be able to discuss also the effects of passive labor market policy on welfare, we again allow for changes in unemployment insurance benefits $b$. In Subsections 5.4.2 and 5.4.3, we then turn to the determination of optimal program size and intensity, respectively.

### 5.4.1. Welfare Effects of Changes in Policy Instruments

In the Appendix we show that the change in program participants’ expected utility (5.6) can be written as

$$\frac{dEU_P}{u'_E} = pp(w - t - b)\hat{\delta} + \Gamma pp(1 - \alpha)\hat{\theta} + (1 - pp)w(1 + \rho)\hat{b} - ppw\hat{t}, \tag{5.24}$$

$$\Gamma \equiv \frac{(y - w)(\gamma - \alpha)}{(1 - \gamma)(1 - \alpha)}.$$

The division by marginal utility $u'_E$ implies changes in income equivalent units. The first term on the right captures the direct impact of a higher employment probability due to a more intensive program. As participants become more likely to find a job and realize the income differential between the two employment states, their expected utility increases. The second term relates to efficiency effects of a change in labor market tightness. When workers’ bargaining power $\gamma$ is high relative to the elasticity of the matching function with respect to jobseekers $S$, $\gamma > \alpha$ in $\Gamma$, the bargained gross wage is too high from an efficiency perspective. Consequently, too few firms enter the economy, resulting in inefficiently high unemployment. Because a tighter labor market raises employment, an increase in $\theta$ then improves efficiency in the model. As already shown by Hosios (1990),
when $\gamma = \alpha$, bargaining is efficient and a change in $\theta$ has no direct implications ($\Gamma = 0$) on expected utility. The third term shows the impact of a change in unemployment insurance benefits on participants’ consumption utility. Due to risk aversion, higher benefits imply a higher than one-to-one gain in income equivalent units. Similarly, when the tax rate increases, utility in the employed state is correspondingly reduced, as captured in the last term in (5.24).

Analogously, we can derive the change in non-participants’ expected utility as

$$
\frac{dEU_N}{u'_E} = \Gamma p_N(1 - \alpha)\hat{\theta} + (1 - p_N)w(1 + \rho \chi)\hat{b} - p_N w \hat{t}.
$$

(5.25)

Utility responds in the same manner to changes in $\theta$, $t$ and $b$ as in the case of program participants. The only difference to equation (5.24) is that program intensity does not directly affect workers’ employment prospects, and thus expected utility, here. Dividing equation (5.23) by marginal utility $u'_E$ in the employed state and inserting the results from (5.24) and (5.25), using the equality $\phi p_p + (1 - \phi)p_N = e$ and finally substituting for $\hat{t}$ from (5.17) yields the change in social welfare

$$
\frac{dW}{u'_E} = \phi p_p(w - t - b)\delta + \frac{EU_p - EU_N}{u'_E}(1 - \phi)\hat{\phi} - G_0\delta\hat{\delta} - G_0(1 - \phi)\hat{\phi} + (1 - e)wp\chi\hat{b} + \Gamma e(1 - \alpha)\hat{\theta} + \epsilon wo\hat{c}.
$$

(5.26)

In this exposition, we see the direct effects of changes in the policy instruments and their implied impacts on efficiency. Higher program intensity stimulates employment probabilities of participants (as in (5.24)), and a larger program size lets more individuals attain expected utility $EU_p$ instead of $EU_N$. We know from the discussion in Subsection 5.2.1 that this difference is positive. However, program costs $G$ rise in both program characteristics, which reduces resources available for taxpayers. The second term on the second line of (5.26) shows the gains from insurance that arise when the unemployed receive a higher transfer. This gain increases with the risk aversion parameter $\rho$ and the income difference in the two employment states, as captured in $\chi$. The next expression corresponds again to the possible inefficiency of wage bargaining and the ensuing implications that arise from a change in market tightness, as discussed below equation (5.24). The last term in (5.26) reflects the excess burden of the welfare state. From the workers’ point of view, the participation tax $t^*$ constitutes the fiscal cost of the transition from unemployment to employment and thus negatively affects employment decisions. An increase in employment $e$ reduces this excess burden and raises welfare.
5.4.2. Program Introduction and Optimal Program Size

Using (5.26), social welfare changes with the size of the job search assistance program according to (remember that \( d\phi = (1 - \phi)\hat{\phi} \))

\[
\frac{dW}{u'_E \cdot d\phi} = \frac{EU_P - EU_N}{u'_E} - G\phi + \Gamma e(1 - \alpha) \frac{\hat{\theta}}{d\phi} + ewt^r \dot{e}.
\]

Inserting for the effect on the employment rate from (5.22) shows that the direct fiscal implications of program enlargement stem from increased revenues in the form of the participation tax from those workers who are additionally employed because of their program attendance, minus the direct marginal program costs. These two effects can be summarized again by using \( \xi \):

\[
ewt^r \delta s_p - s_N - G\phi = -ew\xi.
\]

Further summarizing \( ew + ewt^r \frac{\psi_p}{\Psi} = \frac{ew}{\Psi} \) and using (5.16) and (5.19) finally yields

\[
\frac{dW}{u'_E \cdot d\phi} = \frac{EU_P - EU_N}{u'_E} - ew\xi \frac{\psi_p}{\Psi} - \Gamma e(1 - \alpha)w\omega \frac{\xi}{\alpha(y - w)} \frac{\xi}{\Psi}.
\] (5.27)

Apart from the fact that a higher number of participants means that more workers can enjoy expected utility \( EU_P \) instead of \( EU_N \), all direct and indirect implications of an increase in \( \phi \) are proportional to the fiscal net effect \( \xi \). The second term on the right contains the total employment effects, net of the marginal program costs, and is a negative function of \( \xi \). The third term captures again the efficiency effect due to the change in labor market tightness, and is in negative proportion to \( \xi \) for \( \gamma > \alpha \) and in positive proportion for \( \gamma < \alpha \). However, inserting for \( \Gamma \) and \( \omega \) shows that the second and third terms together are always a negative multiple of \( \xi \).

Assuming that \( W \) is a concave function of program size \( \phi \), a necessary prerequisite for the desirability of introducing a job search assistance program is that the derivative of social welfare with respect to \( \phi \) is positive at \( \phi = 0 \). Several factors make this case more likely. First, if the program is highly effective, making the participants’ chances to find employment significantly higher than non-participants’, the difference in expected utilities \( EU_P - EU_N \) and in effective search intensities \( \delta s_p - s_N \) is large. This improves the welfare effects of a program introduction. Secondly, small marginal program costs \( G\phi \) for the first participants also help to justify its implementation.

The third factor is the general level of taxation, which reflects the generosity of the welfare state and the size of other government expenditures. If this level is high it also implies a large participation tax, and a rise in employment due to
the direct effect of the labor market program on participants thus generates large fiscal savings. However, these positive welfare implications are counteracted by the negative impact of high taxes on search efforts for both groups of jobseekers. As the job search incentives of participants are reduced to a greater extent, the relative difference in employment prospects and in expected utility shrinks. In the Appendix, we show for the case of $\gamma = \alpha$, i.e. when the Hosios condition is met, that the first effect dominates when tax levels are so high that $\xi < 0$. Thus, the welfare effects of program introduction are more beneficial if the economy has a high general level of taxation.

This finding can to some extent explain why countries with high levels of labor income taxation like Belgium, Denmark, Finland, Germany, the Netherlands or Sweden run a large number of active labor market programs at the same time (cf. OECD, 2006). The initial fiscal gains that can be generated by employment enhancing policies are then so large that they can justify the additional outlays for these activation measures.

It is also conceivable that all workers in the economy optimally participate in the program. Formally, this requires the derivative of social welfare in (5.27) to be positive at the maximal size $\phi = 1$. In this case, the effectiveness of the program relative to the marginal costs of program expansion would have to be high even when already many workers attend the program.

If the derivative of social welfare in (5.27) is positive at $\phi = 0$ and negative at $\phi = 1$, the optimal size of the job search assistance program is determined by the condition

$$\frac{EU_P - EU_N}{u'_E} = \left( ew + \frac{1 - \alpha}{\alpha(y - w)}\right) \frac{\xi}{\Psi}.$$  

As the term on the left-hand side is positive (see Subsection 5.2.1), and inserting for $\Gamma$ shows that the sum in brackets is also greater than zero, the net tax effect $\xi$ of a higher program size must be positive as well. The marginal program costs should thus be higher than expected public savings from the direct increase in the employment probability of the marginal attendant. From a distributional perspective, the search assistance program creates inequality between the groups of participants and non-participants, and the gain in expected utility that the marginal participant can obtain compensates for the consequences of a marginal increase in the required tax level and ensuing equilibrium effects. These include negative general equilibrium effects on employment and, if wage bargaining leads to inefficiently high unemployment (in the case of $\gamma > \alpha$), reduced labor market
tightness further removes the equilibrium from the first-best. This optimality condition can be compared to the recommendations for program assignment made in OECD (2005, Chapter 5). It is argued there that programs should be chosen according to the fiscal savings they generate in the form of the participation tax, which should exceed their costs. Our optimality condition for program size makes clear that when placement officers decide on assigning a jobseeker to a particular program that is already in place, they should make sure to consider the marginal program costs that follow from an additional participant. Depending on the size of the fixed costs of a program, these can be higher or lower than the average costs, which are for instance normally reported in cost-benefit analyses (cf. Dolton and O’Neill, 2002; Van Reenen, 2004). Further, this decision rule ignores that the job search assistance program has direct benefits for its participants, which improves the expected utility of an individual before program assignment has taken place. In fact, the rule maximizes expected utility of non-participants (see equation (5.25)). From the point of view of a person who does not yet know if he will be assigned to participate in the job search assistance program, this would lead to a too small program size.

5.4.3. Optimal Program Intensity

Now turning to the analysis of optimal program intensity, the derivative of social welfare with respect to \( \delta \) follows from inserting the changes in the employment rate (5.22) and in market tightness (following from (5.16), (5.12) and (5.19)) into (5.26) and summarizing as above:

\[
\frac{dW}{u'_E \cdot d\delta} = \phi s \rho m_0 \theta^{1-\alpha} (w - t - b) - e w \frac{\lambda}{\Psi} \Gamma e \frac{(1 - \alpha) w \omega}{\alpha (y - w)} \frac{\lambda}{\Psi}.
\]

(5.28)

Analogous to the case of program size, the second term on the right captures both the direct fiscal consequences of a change in program intensity for taxpayers and the general equilibrium implications that affect employment. Both effects are proportional to \( \lambda = \frac{C_0}{\epsilon w} - t^* (1 + \sigma) \frac{\phi s \rho}{\gamma} \), as is the impact on efficiency due to a change in labor market tightness (third term). Inserting for \( \Gamma \) and \( \omega \) shows that the two terms taken together are a negative multiple of \( \lambda \).

A more intensive labor market program has always a positive direct impact on the probability to find a suitable occupation for its participants. They are thus more likely to gain the consumption utility differential between the two employment
states, which is approximated by the income difference \( w - t - b > 0 \). However, in spite of this positive direct effect, very high marginal program costs \( G_\delta \) that lead to \( \frac{dW}{u'_E \delta} < 0 \) will prevent the implementation of an effective job search assistance program. It is then optimal to set both program size and intensity to zero.

In contrast, if program costs are rather small initially, the optimal program intensity is determined by the condition

\[
\phi_{SP} m_0 \theta^{1-a} (w - t - b) = \left( ew + \frac{\Gamma e (1 - \alpha) w \omega}{\alpha (y - w)} \right) \frac{\lambda}{\Psi}. 
\]

As the left-hand side and the term in brackets are positive, optimality requires that the net fiscal effect \( \lambda \) is also positive. The marginal gains of a more intense program, consisting of the direct increase in employment prospects and, consequently, expected utility of participants, then offset the marginal costs in the form of a higher labor income tax and ensuing general equilibrium effects. The equilibrium feedback on aggregate employment is thus negative at the margin, implying a corresponding efficiency cost. Further, if the workers’ bargaining power is larger than the elasticity of the matching function with respect to jobseekers, i.e. \( \gamma > \alpha \), the labor market exhibits inefficiently high unemployment. The reduction in labor market tightness brought about by the tax increase then further adds to this inefficiency and constitutes an additional marginal cost of the policy.

Finally, comparing the effects of program size and intensity on social welfare in (5.27) and (5.28) makes clear that both characteristics have the same types of efficiency costs, as they affect social welfare through the same equilibrium channels. Thus, in the event that both instruments optimally take interior values, they must jointly satisfy the simple condition

\[
\frac{EU_P - EU_N}{u'_E \cdot \phi_{SP} m_0 \theta^{1-a} (w - t - b)} = \frac{\xi}{\lambda}. 
\]

The left-hand side shows the ratio of the direct marginal effects of an increase in program size and in program intensity, while the right-hand side shows the ratio of the corresponding direct marginal effects on the tax rate. Thus, if the gain in expected utility of program participants due to an intensification of the program is higher than the gain in expected utility for the marginal participant if the program is expanded, it is also optimal to accept a greater rise in the required tax on labor income in the case of program intensification.
5.5. Conclusion

Job search assistance programs aim at improving the job search skills of the unemployed and are generally found to be among the most effective active labor market policies for a broad range of participants. Being also relatively inexpensive compared to other activation measures, in many countries a large share of insured jobseekers are assigned to attend these programs. It follows that in addition to the direct implications of programs on their participants, their macroeconomic effects must also be expected to be significant, and it is all the more important to design these programs in a way that is beneficial for social welfare.

This paper thus develops the optimal rules for determining the two most important characteristics of such a program, i.e. its size and intensity. It is found that both characteristics have positive direct effects on their participants (or the marginal participants in the case of program size). They follow from the direct stimulation of attendants’ employment probability, which is generally the focus of the microeconometric evaluation literature. These positive direct effects are traded off against the program’s implications for the labor income tax, which consist of a positive component in the form of direct program costs and a negative component in the form of an enlarged tax base due to the direct employment stimulation of the policy. We find that the net tax effects of both instruments should be positive at the margin. This then provokes also a distortion in employment and might further remove labor market tightness from its efficient level.

In addition, we find that the implementation of a job search assistance program can enhance social welfare only if it sufficiently raises the job finding rates of participants and is not too costly already for small numbers of participants. Furthermore, if the general level of labor income taxes is high, for instance due to a large welfare state, a program is also more likely to improve welfare. The fiscal gains from the participation tax paid by the additionally employed are then higher and can compensate for the dilution of search incentives.
Appendix

Proof of $EU_P > EU_N$ for $\delta > 1$: Here, we show that $EU_P > EU_N$ for $\delta > 1$. Using the optimality conditions (5.5) and (5.7) for job search efforts, the difference between indirect expected utilities of program participants (5.4) and of non-participants (5.6) can be written as (remember that $p_P = \delta s_P m_0 \theta^{1-a}$ and $p_N = s_N m_0 \theta^{1-a}$):

$$EU_P - EU_N = p_P (u(w - t) - u(b)) - \varphi(s_P) - [p_N (u(w - t) - u(b)) - \varphi(s_N)]$$

Further, we know that $s_P > s_N$ for $\delta > 1$. It is therefore sufficient to show that the function $\mu(s) = s \varphi'(s) - \varphi(s)$ is monotonically increasing. The derivative of this function is $\mu'(s) = s \varphi''(s)$. As we have assumed that the search cost function is strictly convex, $\varphi''(s) > 0$, it follows that $\mu'(s) > 0$.

Derivation of equation (5.24): Differentiating equation (5.6) and applying the optimality condition for job search (5.7) yields

$$dEU_P = p_P [u_E - u_B] \left( \hat{p}_P - \hat{s}_P \right) + p_P w u'_E (\hat{w} - \hat{t}) + (1 - p_P) w (1 + \rho \chi) \hat{b}$$

Using the approximations for $u_B$ and $u'_B$ stated above, dividing by $u'_E$ and substituting $\hat{p}_P = \hat{\delta} + \hat{s}_P + (1 - \alpha) \hat{\theta}$ leads to

$$\frac{dEU_P}{u'_E} = p_P (w - t - b) \left( \hat{\delta} + (1 - \alpha) \hat{\theta} \right) + p_P w (\hat{w} - \hat{t}) + (1 - p_P) w (1 + \rho \chi) \hat{b}$$

Finally, inserting from (5.16), substituting from the wage bargaining condition (5.9) and rearranging yields equation (5.24). Derivation of equation (5.25) starts out from equations (5.4) and (5.5) and then follows exactly the same steps.

Program introduction: This section shows that program introduction is more likely to be welfare improving if the overall level of labor income taxes and thus also the participation tax are high. For simplicity, we assume that $\gamma = \alpha$, implying $\Gamma = 0$. We consider an increase in $t$, assuming that the rise in tax revenues
is neither spent on unemployment insurance nor on the job search assistance program (equation (5.17) therefore does not hold). From (5.27), we derive

$$\frac{d^2W}{d\phi dt} = \frac{dEU_p}{dt} - \frac{dEU_N}{dt} - \frac{u'_E d(\xi w)}{\Psi dt} - \frac{\Delta u'_E \xi w}{\Psi^2 dt} + u'_E \xi w \frac{d\Psi}{dt}.$$

(5A.1)

From (5.24) and (5.25) it follows that \(\frac{dEU_p}{dt} - \frac{dEU_N}{dt} = -u'_E(p_p - p_N)\). The third term on the right simplifies to \(\frac{d(\xi w)}{dt} = -\frac{d(\xi w)}{dt} (p_p - p_N) - w \frac{\partial \rho}{\partial p} \frac{p_p - p_N}{p_N} \), where we have made use of the identity \(\frac{d(\xi w)}{dt} = \frac{\partial \rho}{\partial e} \). Use \(\frac{d(\xi w)}{dt} = 1\) and \(\frac{\partial \rho}{\partial p} \frac{p_p - p_N}{p_N} = -\frac{\psi}{\omega} (p_p - p_N)\), which follows from inserting \(\hat{p}_p = \hat{\delta} + \hat{s}_p + (1 - \alpha)\hat{\Theta}\) and \(\hat{p}_N = \hat{s}_N + (1 - \alpha)\hat{\Theta}\), applying (5.13), (5.14), (5.16) and (5.12) and using the definition of \(\psi_p\) in (5.21). We therefore have \(\frac{u'_E d(\xi w)}{\Psi dt} = -u'_E(p_p - p_N)\), where we have used \(\Psi = 1 - t\psi_p\). The first three terms on the right of (5A.1) thus just cancel.

In the fourth term, \(\frac{\Delta u'_E}{dt} = -u''_E(1 - \omega)\), which is positive as the utility function \(u\) is concave. To derive \(\frac{d\Psi}{dt}\), we use \(\frac{d\sigma}{dt} = \frac{1}{w}(1 - t\omega)\) and \(\frac{dw}{dt} = \omega\) to get in a first step

$$\frac{d\Psi}{dt} = -\left(\frac{\sigma(1 - \omega)}{1 - t\omega} + (1 + \sigma) \frac{(1 - \alpha)\omega}{\alpha(y - w)} \right) \frac{1 - t\omega}{w} - t^* \sigma \frac{(1 - \alpha)\omega^2}{\alpha(y - w)} \left(1 + \frac{w}{y - w}\right)$$

$$+ \left(\frac{\sigma t^* - t^*(1 + \sigma) \frac{(1 - \alpha)\omega}{\alpha(y - w)} \frac{d\omega}{dt}\right).$$

(5A.2)

where \(\frac{d\omega}{dt} = \frac{(1 - \gamma)\rho \chi(1 - \omega)^2 - 1}{(1 + (1 - \gamma)\rho \chi)} \omega(1 - t)\). Using the approximation \(u_B \approx u_E - (w - t - b)u'_E\) in the wage bargaining condition (5.9) and the assumption \(\gamma = \alpha\) lets us summarize the terms in brackets on the second line by \(-\frac{t^*}{1 - t}\). Thus, the first two terms in (5A.2) are negative, while the third is positive. To derive the sign of the overall expression, rearrange (5A.2) to summarize all terms that are not multiplied by \(\sigma\), while again using the approximation of (5.9) and the definition of \(\omega\) in (5.12):

$$\frac{d\Psi}{dt} = -\left(\frac{\sigma(1 - \omega)}{1 - t^*} + \sigma \frac{(1 - \alpha)\omega}{\alpha(y - w)} \right) \frac{1 - t^* \omega}{w} - t^* \sigma \frac{(1 - \alpha)\omega^2}{\alpha(y - w)} \left(1 + \frac{w}{y - w}\right)$$

$$- \frac{\omega}{w(1 - t^*)} \left(1 + \frac{(1 - \omega) t^*}{1 - t^*} \left(1 + \rho \chi - \frac{\rho \chi}{1 + \rho \chi} (1 - \chi)(1 - \omega)\right)\right) < 0.$$

Clearly, as \(0 < \omega, \chi < 1\), the third term is also negative and the whole derivative is smaller than zero. Consequently, the sign of \(\frac{d^2W}{d\phi dt}\) is solely determined by the sign of \(\xi\):

$$\text{sign}\left(\frac{d^2W}{d\phi dt}\right) = -\text{sign}(\xi).$$

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In situations of program introduction when we have high levels of taxation and consequently a high participation tax, leading to $\xi < 0$, the effect on welfare is thus more beneficial than when taxes are low.


Curriculum Vitae

Education

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