Destruction and Reallocation of Skills Following Large Company Closures

Jacob Rubæk Holm (corresponding)
Department of Business and Management, Aalborg University
Fibigerstræde 11, 9220 Aalborg Ø, Denmark
jrh@business.aau.dk

Christian Richter Østergaard
Department of Business and Management, Aalborg University
Fibigerstræde 11, 9220 Aalborg Ø, Denmark
cro@business.aau.dk

Thomas Roslyng Olesen
Department of Innovation and Organizational Economics, Copenhagen Business School
Kilevej 14A, 2000 Frederiksberg, Denmark
tro.ino@cbs.dk

Abstract

This paper analyzes what happens to redundant skills and workers when large companies close down and whether their skills are destroyed or reallocated. The analysis is based on a combination of qualitative and quantitative data of the closure of four companies. Getting a job in a skill-related industry or moving to a spinoff firm leads to skill reallocation. Thus, the result depends on regional idiosyncrasies such as industry structure and urbanization. If local policy makers and the owners exert a coordinated effort, it is possible to create success stories of less skill destruction in urban as well as peripheral regions.

Acknowledgements: This research is funded by the GONE project sponsored by the Danish Council for Strategic Research. The authors are grateful for comments from participants at the Workshop on Industry relatedness and Regional Qualitative Change 2013 in Aalborg,

participants at the 2nd Geography of Innovation Conference 2014 in Utrecht, and the reviewers and editors of this journal.

Keywords: Knowledge flows; Company closure; Skill relatedness; Evolutionary economic geography; Genetic matching

JEL: R11; J24; J65; L62; B52

1 INTRODUCTION

When a large company closes down in a region, the skills, competencies, and knowledge embodied in the displaced employees are suddenly released and can become channels of knowledge transfer for other firms that hire them (Almeida and Kogut, 1999; Song, Almeida, and Wu, 2003; Boschma, Eriksson, and Lindgreen, 2009; Hoetker and Agarwal, 2009; Malecki, 2010; Timmermans and Boschma, 2014) and for spinoff firms (Buenstorf and Fornahl, 2009). Thus, company closures might lead to reallocation of skills, destruction of skills, or both. Creative destruction of firms, jobs, routines, and skills is a common element of regional development and change processes (Neffke, Henning, and Boschma, 2011; Fingleton, Garretsen, and Martin, 2012). These processes can be very disruptive. For instance, when a large company closes down, displacing thousands of workers over a short period of time, it may constitute a shock to the regional economy and lead to unemployment and skill destruction (Hudson and Sadler, 1985; Herzog Jr. and Schlottmann, 1995; Tomaney, Pike, and Cornford, 1999). The questions then are: Under which conditions are the redundant workers and their skills reallocated to productive use elsewhere in the regional economy? Under what circumstances do the workers find jobs where they must start over by acquiring new skills (skill destruction)?

Company closure is an important process in regional development, but studies focusing on how displaced workers' knowledge, or skills more specifically, are reallocated or destroyed are scarce (Neal, 1995; Parent, 2000; Sofka, Preto, and de Faria, 2014). To our best knowledge, the study presented in the current paper is the first investigation of how regional conditions affect what happens to the employees after the closure of large companies and how their skills are reallocated, from the perspective of the employees. We approximate the reuse of skills in the new job by its wage; that is, how the new employer values the employee's skills (Neal, 1995;

Parent, 2000; Sofka, Preto, and de Faria, 2014). We argue that skill reallocation and destruction depend on the presence of skill-related industries in the region and that employees are more likely to have their skills reemployed when they find new jobs in industries that require highly related skills than when they move to unrelated industries (Puga, 2010; Neffke, Henning, and Boschma, 2011; Neffke and Henning, 2013). Furthermore, the result also depends on how the company closes down and whether the mobility is direct or indirect job-to-job mobility.

To study regional differences in these processes of skill destruction and reallocation, we use the closure of four shipyards in Denmark from 1987 to 2000. The analysis is based on detailed longitudinal micro-data from a matched employer-employee dataset that allows us to follow the mobility of the laid-off employees in great detail. We also use qualitative data on the closure processes to aid in interpreting results from matching, including internal materials from the shipyard archives and eight semi-structured interviews with former shipyard managers and employees.

The paper is structured as follows: theories on regional economic evolution and the destruction and reallocation of skills following a large company closure are presented in Section 2. Section 3 describes the processes of closing down four shipyards. Section 4 presents the data and methodology, and in Section 5, the extent of skill destruction and reallocation is analyzed empirically. Section 6 discusses regional differences in the destruction and reallocation of skills, and Section 7 offers the conclusion.

2 LARGE COMPANY CLOSURES, LABOR MOBILITY, AND REALLOCATION OF SKILLS

Previous Studies of Large Company Closures

There is a large amount of literature on large company closures in the field of economic geography that either focuses on the closure processes of plants and policies related to this process, or on the impact of firm closures on the displaced workers' careers and on regional economies (Hudson and Sadler, 1985; Herzog Jr. and Schlottmann, 1995; Tomaney, Pike, and Cornford, 1999; Hill and Markussen, 2000; Chapain and Murie, 2008; Bailey, Chapain, and de Ruyter, 2012; Otto, Eriksson, and Henning, 2015). The literature is mainly based on single cases and it finds that many redundant workers get new jobs shortly after closures and that unskilled and older workers have difficulties finding new jobs (Tomaney, Pike, and Cornford, 1999; Chapain and Murie, 2008). Bailey, Chapain, and de Ruyter (2012) found that the displaced MG Rover workers on average earn less in their new jobs due to changing skills and leaving well-paid unionized work, but some workers' earnings actually increase. Tomaney, Pike, and Cornford's (1999) study of displaced Swan Hunter shipyard workers showed that 60 percent of the workers who found a new job were not using all the skills they had acquired at the shipyard. These studies suggest that many displaced workers experience skill destruction, but they offer only little explanation on the differences in the extent of the skill destruction among workers.

Only few studies have been made on the consequences of shipyard closures and the re-employment of workers, but these studies do not focus on how their skills are either reallocated or destroyed (Withington, 1989; Andersen, 1996; Andersen and Storrie, 1996; Storrie, 1996; Tomaney, Pike, and Cornford, 1999; Ohlsson and Storrie, 2012). Andersen and Storrie (1996)

examined the causes for early retirement after shipyard closures in Elsinore, Denmark, and Uddevalla, Sweden, and Whithington (1989) examined the sociological consequences of the closure of Smith's Dock in Middleborough, UK. Tomaney, Pike, and Cornford (1999) analyzed the closure of the Swan Hunter shipyard in the UK and found that different groups of workers with different skill profiles had different labor market prospects. The most recent study by Ohlsson and Storrie (2012) focused on the long-term effects of public policy for displaced workers in Sweden. There are also more general studies on the decline of the shipbuilding industry (Eich-Born and Hassink, 2005; Hassink, 2010) and the restructuring of old industrial regions (Tödtling and Trippl, 2004; Hassink and Shin, 2005; Martin and Sunley, 2006). These studies suggest that regions can be overspecialized in specific industries, which often leads to a lock-in and a subsequent decline when the industry fails to renew itself or adapt to changes. However, there is little analysis or discussion of the fate of displaced workers and the destruction of their skills in the processes of decline and restructuring. Similarly, Bailey, Chapain, and de Ruyter (2012) argued that restructuring and the role of policy are not just about providing jobs, but also about the quality of the new jobs.

Labor Mobility and Knowledge Flows

How regional industry structures diversify over time is a key issue in evolutionary economic geography. The economic evolution of regions is affected by entrepreneurship and job creation, and also by the creative destruction of industries, firms, and skills. As a result, even stable regional economies are facing a continuous turnover in firms and jobs that require the use of different skills (Rigby and Essletzbichler, 2000; Essletzbichler, 2004; Brown, Lambert, and Florax, 2013). Recently, attention has focused on regional branching, where regional industries and firms tend to diversify into technology-related or skill-related areas defined in terms of their

knowledge base, human capital, and skills (Boschma and Frenken, 2011; Neffke, Henning, and Boschma, 2011; Boschma, Minondo, and Navarro, 2013; Neffke and Henning, 2013; Essletzbichler, 2015).

A key factor in these processes is the flow of knowledge and skills embodied in the firms' employees through spinoffs or labor mobility (Boschma and Frenken, 2011). Labor mobility is often considered an important, inter-firm knowledge-transfer mechanism that also allows the transfer of tacit knowledge such as skills (Almeida and Kogut, 1999; Song, Almeida, and Wu, 2003; Boschma, Eriksson, and Lindgreen, 2009; Malecki, 2010; Boschma and Frenken, 2011). Additionally, knowledge transfer and learning are more likely to occur between cognitively close organizations (Nooteboom, 2000; Song, Almeida, and Wu, 2003). Therefore, labor mobility between related industries is more likely to lead to knowledge transfer, while mobility between unrelated industries not only leads to "new knowledge" in the receiving firm, but also to increased costs of communication and interaction between the two different knowledge bases. As a result, mobility between unrelated industries renders some of the new employees' knowledge and skills obsolete because they are too distant from the knowledge and skills required in the new job.

A portion of the knowledge embodied in a firm is lost when it closes down because the firm's knowledge is more than the sum of the knowledge of its employees. Nonetheless, the skills, competencies, and knowledge embodied in displaced employees can lead to knowledge transfer through mobility to other firms (Hoetker and Agarwal, 2009). However, as argued above, the extent of knowledge transfer or skill reallocation likely depends on the relatedness of the knowledge base between the workers and the hiring firms. Similarly, Palomeras and Melero (2010) argued that mobility allows for knowledge transfer if the knowledge distance is not too

far to create complementarities, but it also leads to destruction of the knowledge that is specific to the old firm. Studies on displaced workers also find that replacement costs of the workers in terms of lower wages are less for those who stay in the same industry or move to related industries and perform similar types of routines (Neal, 1995; Gathmann and Schönberg, 2010; Schwerdt, 2011).

This indicates that the level of skill destruction is lower for workers who are able to find jobs in skill-related industries, while workers who switch to unrelated industries suffer from greater skill destruction, since their new employers assign little value to their specific skills.

Hypothesis 1: The extent of skill destruction is less for displaced workers who find jobs in skill-related industries compared to workers who find jobs in unrelated industries.

The geographical mobility of workers from a workplace that closes down is limited and quite similar to other types of mobility. Based on Danish data, Dahl and Sorenson (2010) found that proximity to the current home is the most important factor in job mobility for workers from a closing workplace. Since the extent of skill reallocation and destruction depends on movement to a related industry, the availability of related industries in a region is likely to limit the overall extent of skill destruction. Furthermore, the exit of an industry in a region can trigger the exit of a set of related industries if these become unrelated to the regional industrial portfolio (Eich-Bohn and Hassink, 2005; Neffke, Henning, and Boschma, 2011).

Hypothesis 2: The extent of skill reallocation or destruction of displaced employees depends on the presence of skill-related industries in the region.

The existing literature on industry relatedness does not distinguish between moving directly between jobs and indirect mobility where there is a period of either unemployment or of being

out of the labor market. Direct mobility is encouraged by opportunities to reallocate skills and is discouraged by potential skill destruction.

Hypothesis 3: Direct mobility leads to less skill destruction compared to indirect mobility.

Closing a plant can differ between an orderly process where the firm tries to sell off activities and support the establishment of spinoffs, and a chaotic process where there is no attempt to maintain the company's profitable operations and it falls apart in a disorderly fashion. Managers play an important role in this process and their decisions influence the type of exit. Managers might try to reduce exit costs by selling off parts of the company or allowing parts to spin off through management buy outs (Clark and Wrigley, 1997). Spinoffs are a way to replicate the routines of the existing company (Boschma and Frenken, 2011). Additionally, sometimes mass layoffs set a spinoff process in motion that leads to the formation of many new companies (Eich-Bohn and Hassink, 2005; Buenstorf and Fornahl, 2009). Thus, the displaced workers who obtain jobs at either the parent or entrepreneurial spinoffs from the exiting company are likely to enter jobs where they can reuse their skills.

Hypothesis 4: Finding employment at a spinoff company leads to less skill destruction.

However, not all displaced workers find new jobs. Some end up being unemployed for a long period or are, to some extent, forced into retirement (Herzog Jr. and Schlottmann, 1995; Tomaney, Pike, and Cornford, 1999). Other workers reenter the education system for a period to upgrade their formal education. Both processes lead to a destruction of the skills related to the closed firm. However, by acquiring a new education, the worker gains new skills.

3 DECLINE OF THE DANISH SHIPBUILDING INDUSTRY

The Danish shipbuilding industry used to be a large industry, closely connected to the large, Danish commercial fleet. During the 1970s and 1980s, it faced increased competition, particularly from Korean and Japanese shipyards, as did the rest of the European shipbuilding industry. Employment in the Danish shipbuilding industry dropped from 18,000 in 1982 to 5,000 in 2007 (Poulsen and Sornn-Friese, 2011). The closure of shipyards across Denmark was thus not so much economic selection among companies but rather the consequence of selection among national shipbuilding industries.

Shipbuilding was considered to be a medium, technically advanced industry that employed many skilled workers, and the Danish shipbuilding industry was characterized by technological development, innovation, and niche production (Poulsen and Sornn-Friese, 2011). Shipbuilding was traditionally a cyclical industry that was sensitive to changes in the business cycle. As a result, most shipyards also did repair work and had somewhat diversified production lines in order to retain the workforce during recessions.

The following sections describe the processes of closing down four shipyards. The intention is to highlight the differences among the four regions, closure processes, ownership structures, product portfolios, and organizations, as these are expected to contribute to explaining the differences in the results of the quantitative analyses in Section 5.

Aalborg Værft

Aalborg Værft was controlled by the Danish shipping conglomerate, J. Lauritzen, at the time of its closure in 1988. At that time, J. Lauritzen also owned the Danyard in Frederikshavn and a third shipyard in Elsinore, as well as several other firms. Due to the increasing competition from

shipyards in Asia, the company began building advanced ships such as reefers and passenger ships. The R&D department employed highly skilled engineers. The shipyard furthermore worked as a ship interior subcontractor for other European shipyards. The most important side activity was the development and production of marine and industrial boilers. The low demand for new ships after the oil crisis forced the shipyard into the offshore sector, and when it closed down, it had three separate divisions: offshore, boilers, and shipbuilding. However, over its lifetime, it had at various times diversified more widely and produced residential houses, steel bridges, and refrigerators, among other things (Nielsen, 2012; Olesen, 2012a). Aalborg Værft was situated in the northern part of Jutland in Aalborg, a city of 100,000 inhabitants, which had a strong regional shipbuilding industry with several nearby steel-shipyards and marine suppliers (Olesen, 2012a).

The closure took place in two phases—both on short notice. After a number of years of good financial performance, a lack of new orders, combined with serious problems in the offshore division, resulted in a very large deficit in 1986. Despite various attempts to mend the situation during 1987, the management decided to shut down all steel shipbuilding activities in March 1988 (Board Protocols from Aalborg Værft, 1986–1987; Annual Reports Aalborg Værft, 1975–1990; Nielsen, 2012; Olesen, 2012a).

During 1987, the management made several attempts to maintain a skill base of around 700 employees by transferring employees from shipbuilding to the boiler and offshore divisions. The management made an effort to identify and continue the profitable activities, leading to the establishment of several spinoff companies. The boiler division was spun off into two new firms: Aalborg Boilers Land and Aalborg Marine Boilers (Board Protocols from Aalborg Værft, 1986–87; Olesen, 2012a).

The closure in March 1988 saw no attempts to retain the employees, as the decision was made on very short notice, and the remaining ship would be finished at Danyard in Frederikshavn. However, the closure also resulted in a few spinoffs, including fiberglass ship construction and the production of steel elements. The shipyard site was transformed into a business park that housed most of the spinoff activities, and Aalborg Værft continued as a real estate company in the business park (Board Protocols from Aalborg Værft, 1987–1990; Annual Reports from Aalborg Værft, 1980–1991; Olesen, 2012).

Danyard Frederikshavn

Danyard Frederikshavn was also owned by J. Lauritzen at the time of its closure in 1999. From the late 1970s, the shipyard specialized in a variety of niche productions ranging from ferries and naval ships to reefers and highly specialized chemical tankers. The shipyard had its own R&D department but no important related activities besides shipbuilding. The chemical tankers were, however, so specialized that the production site effectively included a pipeline factory (Olesen, 2013).

Danyard was situated in northern Jutland in the town of Frederikshavn with 25,000 inhabitants. Danyard was part of a strong regional shipbuilding industry that included the neighboring Ørskov Steel Shipyards and Karstensens in nearby Skagen, as well as a large number of suppliers. Most of these companies operated in an international market and were not solely dependent on Danyard (Olesen, 2013).

Danyard Frederikshavn exhibited poor financial performance over a number of years in the mid-1990s, and, in October 1998, it was decided that the company would be closed down when the remaining orders had been completed. In an attempt to finish the remaining orders on time, the

management decided not to inform the employees beforehand of its decision to close the shipyard. However, to reduce costs, the management was forced to begin laying off workers, and by January 1999, it was obvious that the shipyard would close down (Board Protocols Danyard, 1990–2000; Annual Reports Danyard, 1990–2000; Christensen, 2010; Olesen, 2013).

Through 1999, the management worked to spin off activities that could be continued after the shipyard closure. This included a pipeline factory and an engineering company. A business park was established as a daughter company of J. Lauritzen, and the neighboring Ørskov Christensen Steel shipyard decided to buy a considerable part of the Danyard site (Board Protocols Danyard, 1999; Annual Report, 1999; Olesen, 2013).

Nakskov Skibsværft

Nakskov Skibsværft was located in the town of Nakskov on the island of Lolland. Since 1939, the shipyard had been fully owned by the East Asiatic Company (EAC), which was one of the major Danish shipping conglomerates in the 1980s. Nakskov Skibsværft specialized in small, complicated ships such as ferries and product carriers. Apart from shipbuilding, the shipyard produced steel bridge sections and attempted to diversify into the offshore sector (Olesen, 2012b).

Nakskov shipyard was situated in the peripheral region of Lolland-Falster with above average unemployment and there were only a few small and medium-sized industrial companies and no nearby shipyards in the area. Nakskov Skibsværft was, thus, an important workplace for the 14,000 inhabitants in Nakskov. The company performed poorly in the early 1980s. Only direct intervention by the Danish government, which decided to order two new ferries for the state

railway company, kept the shipyard from closing down (Board Protocol Nakskov Skibsværft, 1980–1986; Annual Reports Nakskov Skibsværft, 1980–1986; Olesen, 2012b).

However, in July 1986, the management announced that the shipyard would close after the completion of the remaining orders, and in December, all activities were shut down (Board Protocol Nakskov Skibsværft, 1986; Annual Reports Nakskov Skibsværft, 1986; Olesen, 2012b).

The EAC made an effort to support the local community when closing the shipyard. In collaboration with a number of financial companies and other organizations, the EAC established a foundation to finance business development in western Lolland. It acted as an important investor in new businesses in the region and helped attract other companies to the region. A number of jobs were transferred to spinoff companies within repair activities, steel construction, and engineering consultancy based on R&D activities at the shipyard. At the time of the closure, the shipyard site was turned into a business park (Board Protocol Nakskov Skibsværft, 1986–87; Olesen, 2012b).

Burmeister & Wain

Burmeister & Wain Shipyard (B&W) was established in July 1980 as a spinoff from the defunct Burmeister & Wain Group. The reconstructed shipyard had no side production, and B&W built non-specialized ships in series, and thus competed directly with the low-cost Asian shipyards. B&W was owned by a group of minority shareholders, including several large pension funds (Hansen, 2008; Olesen, 2012a). The shipyard was situated in the Danish capital, Copenhagen. During the 1980s and the 1990s, most manufacturing companies had moved out of the city, and the number of jobs in the service sector had increased (Maskell, 1986).

B&W was forced into receivership in June 1995 after just one year of poor financial performance. Several attempts were made to reconstruct the shipyard, but infighting among the managers, shareholders, workers, and creditors meant that the plans were never implemented (Board Protocols B&W, 1995–1996; Hansen, 2008).

No activities were continued after the closure. A real estate company was set up to rent out the land and buildings, but no business park was created, and no new companies were established on the former site (Adsersen and Nielsen, 2005; Olesen, 2012a).

The Role of Unions and National Policy

Like governments in most other shipbuilding nations, the Danish government supported the shipyards in the 1980s. The support was given indirectly through tax incentives or directly through government contracts for the navy or the state railway company. After the shipyard closures, however, the government aid stopped completely. This stands in sharp contrast to Sweden, for example, where the state was directly involved in setting up new workplaces at the shipyard sites. When comparing the two strategies, however, the number of jobs created in Sweden and in Denmark did not differ remarkably (Andersen and Storrie, 1996; Ohlsson and Storrie, 2012; Olesen, 2012a).

The workers' unions had a strong position in the Danish shipbuilding industry; however, they were not unified. There was friction between unions representing various crafts and between the local unions and the central negotiators. Shipyard closures were met with strikes and blockades at individual shipyards, but at the top level the unions did nothing to force a government intervention as was seen in other countries (Stråth, 1987). Thus, the workers' unions did not play an important role in the process of creating after-closure opportunities for shipyard workers. This

contrasts the findings from studies of plant closures in other countries, where unions often played an important role in affecting public policy (Hudson and Sadler, 1985; Hill and Markusen, 2000).

4 METHODS AND DATA

Definition of Skills and Relationship to Wage

We approximated the reallocation of skills in the new job based on wages, that is, how the new employer values the employee's skills (Neal, 1995; Parent, 2000; Sofka, Preto, and de Faria, 2014). Wages do not equal marginal productivity but relative wages can be shown to equal relative productivity, except for gender discrimination (Hellerstein, Neumark, and Troske, 1999). A skill may be defined as "… a capability for a smooth sequence of coordinated behavior that is ordinarily effective relative to its objectives, given the context in which it normally occurs" (Nelson and Winter, 1982, p. 73). A dominant element in "the context" is the organization in which the worker is employed, and whether a worker's skills command a higher or lower wage in a given context depends on the match between the skills and the organization. Skills constitute tacit knowledge, which cannot be easily transferred between firms and can only be created through trial-and-error learning (Lundvall, 2004; Malecki, 2010). The fit between a worker's skills and the organization hence increases over time and a drop in wages is to be expected for tenured workers that are displaced (Jacobsen et al., 1993). However, for this study it can be observed that in many cases wages increase: This indicates that workers find new matches that are at least as good as at the shipyard. This is skill reallocation.

A decrease in wage may indicate skill destruction in two conceptually separate forms that we cannot distinguish: the worker may not be able to find a good match and hence cannot apply his/her current skills, or there may be no matches available as the worker's skills have become obsolete. The two forms of skill destruction require different policy responses as the former requires increased allocative efficiency; e.g. unemployment subsidies allowing for longer search or subsidies for migration, while the latter requires retraining of the worker. However, we cannot distinguish between the two and merely focus on assessing the extent of skill destruction and reallocation. It is likely that the closures resulted in a large local increase in the supply of specific skills making it harder for workers to find matches allowing them to apply their skills. There are a number of factors that add noise to relationship between wage and the skill and organization match. These include non-monetary benefits, long-term incentives contract, labor market imperfections, and discrimination (Jacobson, LaLonde, and Sullivan, 1993, Hellerstein, Neumark, and Troske, 1999) but as long as these do not vary systematically between ship building and other industries they merely add noise. There is no reason to expect that non-monetary benefits, incentives contracts or discrimination were more prevalent at the shipyards than elsewhere. Collective bargaining coverage was high at the shipyards but it was just as high in the rest of the labor market so this is not expected to bias our results either.

Data

The quantitative analyses are based on longitudinal registry data from the Integrated Database for Labor Market Research (IDA) supplied by Statistics Denmark (DST). The database contains detailed information on employed persons in Denmark from 1980 onward, including detailed information on their workplaces. The year of closure is defined as the first year in which the company employment levels were so low that it seemed unlikely they would still be producing

ships. This means that Nakskov and Aalborg closed down in 1987, B&W closed in 1996, and Danyard closed in 2000.

The closures of the shipyards were abrupt, but in some cases, the employment at the shipyards starting decreasing in the years prior to the closure. Therefore, it is necessary to include workers who left more than just one year prior to the closure. This means that the set of workers analyzed for any given shipyard is composed of those for whom the shipyard was their primary workplace in any of the three years prior to its closure. The data used for each worker pertain to the last year in which he or she was employed at the shipyard. For each worker, the database is then scanned until seven years after the closure to find out when he or she re-entered employment.

The first row of Table 1 shows the number of workers identified as having worked at a shipyard in any of the three years prior to year zero and is referred to as the gross population. In the second step, we remove workers for whom there are no valid estimates of hourly wage. The most common causes for the lack of a valid estimate for hourly wage is that the worker became self-employed, had irregular working hours, or left the labor market. We lose 9–18 percent of the gross population in this step. In the third step we remove workers for whom we do not have a valid estimate of their hourly wage at the shipyard, and the result is the net population of Table 1. Wages are measured by the hourly wage estimate in IDA; see also Statistics Denmark (1991). There are a number of observations with missing data making 65–79 percent of the gross population is available for quantitative analysis.

[Table 1: Number of workers and percentage of gross population]

Matching

In order to evaluate the hypotheses derived in Section 2, we defined a number of treatment variables and studied the effects of the treatments on workers' wages. Hypothesis 1 was evaluated through a variable defined as not getting a job in a skill-related industry. Hypothesis 2 was evaluated through a comparison of the four cases, relying on the descriptions in Section 3. Hypothesis 3 was evaluated through a variable defined as direct job mobility. Hypothesis 4 was evaluated through a variable defined as finding a job at a spinoff firm. In addition, we defined two additional treatments: moving residence to a new municipality and acquiring a new education.

Due to the possible endogeneity of the treatments, we estimated their effects in a quasi-experimental setting. This entails preprocessing the data to create treatment and control groups for the analysis of each treatment. Any variable that affects both the outcome (wage in the new job) and the probability of the treatments must be identically distributed in the treatment and control groups; that is, the data must be balanced between the groups. The vector of variables, upon which we balance, is referred to as X. The 11 variables contained in X are described below. The process of iteratively applying different matching methods and checking balance is automated with the use of genetic matching (Sekhon, 2011; Diamond and Sekhon, 2013): Based on a treatment variable to delimit the groups and a vector of variables upon which to balance, X, genetic matching determines the weight for each variable in X that results in maximum balance. Genetic matching is a generalization of matching on the Mahalanobis distance (MD) and is identical to matching on the MD of all variables in X are given a weight of 1. Genetic matching automatically updates the weights to minimize the highest p-value in a battery of tests used to assess balance. Two tests are performed on each of the variables in X resulting in a total of 22

tests. In addition to the paired t-test for equal means, we compare Q-Q plots, testing whether the maximum distance between the curves is zero can be rejected.

We are interested in comparing the effects of the five treatments across shipyards, but we will estimate the average treatment effect on the treated (ATT) rather than the average treatment effect (ATE) by the conditional difference-in-difference estimator (CDID). The various treatments studied here more or less constitute choices by workers and there are probably many individual specific effects that thus affect both the assignment into treatment and the outcome. These are controlled for by the CDID estimator. The preference for ATT over ATE is based on a suspicion that the additional assumptions required for estimating ATE do not hold. For further details and a discussion of the chosen approach to matching, see Holm (2016). The research design entails that the outcome variable in our analyses is the change in (log) wage, and the effect of a treatment is expressed as additional wage growth in percentage points. Only when the lowest p-value from the 22 tests exceeds 0.1 do we consider the result to be balanced.

Relatedness

It is imperative to Hypothesis 1 that relatedness is measured as skill relatedness as opposed to the relatedness of the output or technology (i.e., industry classification) of industries. The skill relatedness of industries is reflected in the degree to which labor flows between the industries exceed expected flows under the null hypothesis of unrelated industries (Neffke et al., 2013). This relatively simple version has been found to be just as useful as more complicated versions where the expected flows are based on regression analysis (Neffke et al., 2013). The relatedness of the shipbuilding industry to industry *j* is determined as the ratio of the unconditional probability that a worker enters *j* relative to the conditional probability that a worker enters *j* after having left the shipbuilding industry. This ratio is in the zero to one range for unrelated

industries and in the one to infinity range for related industries, thus in order to make it symmetric we follow Neffke et al. (2013) and standardize the result, r_j, as:

$$Related_j = (r_j - 1)/(r_j + 1). \quad (1)$$

The index takes on values from -1 to 1, with larger negative values indicating more unrelated industries and larger positive values indicating more related industries. The treatment indicator is called *Unrelated* and takes a value of 1 if the worker's new job is in an industry j where $Related_j < 0$. The continuous index is used to describe regional differences in industry structure when discussing the results of matching.

Skill relatedness evolves over time as organizational practices and technology change in a broad sense (Neffke and Henning, 2013), so it is necessary to compute national relatedness indices separately for each shipyard. The indices are computed by pooling interindustry, direct job-to-job mobility for the three years prior to each company closure at the national level. In this way we ensure that we have a large dataset for computing the index, and that the closure itself does not affect the index. The analysis spans a period of 23 years and, in order to have an industry classification that covers the entire period, it is necessary to use DST's industry classification: "111 grouping for publication purposes" based on NACE rev 1.

Other Treatments

Hypothesis 3 implies that generally, direct job-to-job mobility leads to skill reallocation, while an unemployment spell between jobs leads to skill destruction. We define direct mobility as reentering employment within a year of leaving the shipyard without receiving any unemployment benefits in that year. In addition, workers who acquired a new education after leaving the plant are classified as not directly mobile.

Workers are considered to have acquired a new education if their highest or most recent education level when they reenter employment differs from the education they had when they were last observed at the shipyard. Workers are considered to have moved residence when their home municipality at the time of reentering employment differs from their home municipality when they were last observed at the shipyard.

When a new workplace is added to the IDA, it is marked as a spinoff if at least 30 percent of its employees have been transferred from another workplace. These workplaces are identified for each shipyard from two years before the closure to two years after. Most of the spinoff workplaces are absorbed immediately into other, potentially new, firms and are thus not in the database when the workers reenter employment. Therefore, working at a spinoff is defined as working at a firm in which at least one workplace was spun off from the shipyard. The firm may or may not have existed before the shipyard closed down.

Explanatory Variables

Ten variables characterize workers and are constructed from the raw data. From these, a propensity score (PS) is estimated for each treatment. The relevant PS and the ten variables constitute the vector X used for matching. Hourly wage in the last year at the shipyard and wage in the first year of reemployment are both measured as the logarithm of year 2000 US dollars (USD) for all four shipyards. The consumer price index is used as the deflator, and the data is then converted to USD using the average exchange rate of 8.09 DKK/USD for the year 2000.

A dummy variable for female workers is used to control for gender. Age and work experience are continuous variables in years. A dummy is used to indicate whether workers had four or more years of tenure when leaving the shipyard, since the database only goes back to 1980, and

the data on some workers thus do not allow for measuring tenure in excess of four years. There are three categories of education: at most secondary, tertiary non-university, and university. There are also three categories of occupations: white collar, skilled blue collar, and unskilled blue collar. The final variable is a dummy for full-time employment at the shipyard.

Table 2 presents the descriptive statistics. The share of workers receiving a new education is quite low in all cases, but it is nevertheless almost twice as high for Aalborg (5.49 percent) as for Danyard (2.32 percent). The share of workers finding a new job at a spinoff company varies considerably, from more than 1 in 5 for Aalborg to practically none (0.26 percent) for B&W. A relatively large share of workers from B&W and Nakskov moved to new municipalities between leaving the shipyards and finding new jobs. For B&W, this was affected by the relatively small size of municipalities in and around Copenhagen, while for Nakskov, it probably reflected a depopulation trend for this peripheral region. The share of workers moving directly into a new job is higher for Aalborg than for the other shipyards. In all four cases, the share of workers finding a new job in a skill-related industry exceeds 50 percent, so the treatment variable is defined as a job in an unrelated industry. Thus, we expect the effect on wage growth to be negative. Relatively few workers from Aalborg found a new job in an unrelated industry, while the share is 42.73 percent for B&W. The low flows to spinoffs and other related industries in the case of B&W are consistent with the disorderly process of closure for this shipyard.

[Table 2: Descriptive statistics]

There were few workers with a university degree at the shipyards, but the variation in the share of workers with at most secondary education shows that there must have been some variation in the share of workers with other tertiary education. The share of women is low across the

shipyards and the share of workers with full-time employment is uniformly high. The share of workers with tenure of four or more years is markedly higher for Danyard, and to some extent B&W, than for the other shipyards. It seems that Danyard and to some degree B&W had relatively few white collar workers and correspondingly more skilled blue collar workers.

In all four cases, the average age of workers when leaving the shipyard is late 30s, and average work experience varied from 13 to 18 years. The mean wage at the shipyard was lowest for Nakskov and highest in the cases of B&W and Danyard. For the two cases with the highest initial wage, however, the mean change in wage between the shipyard and re-entering employment was negative, at about -10 percent, while wages increased by 4–5 percent in the cases with lower initial wages (Nakskov and Aalborg). The mean wage at the shipyard was lowest at Nakskov, as it had a special agreement with the labor unions to set wages lower. The mean wages at B&W and Danyard were higher than at Aalborg because these shipyards closed down 9–13 years later, and the general standard of living in Denmark had increased. B&W had the highest wage level, which could be explained by a generally higher wage level in Copenhagen than in the rest of Denmark.

5 EFFECTS OF TREATMENTS ON SKILL DESTRUCTION

Table 4 shows the resulting ATT estimates after genetic matching. The ATT is the average effect of treatment on wage growth in percentage points for those workers that received the treatment. The ATT shows the extent to which the treatment aided or hindered the reallocation of skills after the closure of the shipyard. For each combination of shipyard, treatment, and the ratio of control observations to treated observations (1:*M*), the table shows the estimated ATT and the lowest p-value from the tests used to assess balance. If the minimum p-value is below 0.1, the

data are not balanced and hence we do not interpret the ATT estimate. As can be seen from the table, there are a number of instances where we are not able to achieve balance.

[Table 3: Matching results]

The effect of direct mobility is positive and significant in the case of Danyard. Workers who moved directly into a new job experienced an increase in wage growth of about 5 percentage points. In the case of B&W, there is no effect of direct mobility. In the remaining two cases, we are not able to achieve balance. This finding supports hypothesis 3 that direct mobility leads to less knowledge destruction—except where the closure of the shipyard follows the relatively unstructured process experienced at B&W. Finding jobs at spinoffs has a positive and significant effect in all cases except for B&W, where not enough workers received the treatment for an analysis to be conducted. However, the effect varies: in the cases of Nakskov and Aalborg, finding a job at a spinoff increases wage growth by about 7 percentage points, while the effect is 12 percentage points in the case of Danyard. This might indicate that those who are not treated at Danyard experience particularly low wage growth rather than the spinoff treatment has a particularly large effect compared to the other cases. The results indicate that movement to a spinoff means skill reallocation and thus supports hypothesis 4. Finding a job in an unrelated industry had a negative effect in all four cases: workers who find a job in an unrelated industry on average experience 11–14 percentage points less wage growth. Thus, hypothesis 1 is supported.

We are able to achieve balance for all four cases when studying the effect of moving to a new municipality. But only in the case of Aalborg do we find a significant effect. The effect shows that moving increases wage growth by about 4 percentage points. It is interesting that the treatment effect is considerably less than the results of Dahl and Sorenson (2010), who estimated

that a wage increase of 58 percent would be required in order to work at a location that is twice the distance from home as the original workplace. A detailed inspection of the data reveals that many moves are within the same functional urban region (FUR) indicating a social attachment to place. The effect of "move" is not the effect of long distance migration, which thus seems to play a limited role in the reallocation process, but the effect of spatial mobility more generally.

For the final treatment, new education, it has proven relatively difficult to establish a control group that is identical to the treated group. However, in the B&W case, there is a 24 percentage point effect of new education. For the Danyard case, there is a 20 percentage point effect. The positive effect of re-education indicates that there is leeway for a policy offering re-education to displaced workers when large firms close down.

6 REGIONAL DIFFERENCES IN DESTRUCTION AND REALLOCATION OF SKILLS

To understand what supports skill reallocation rather than skill destruction, the matching results are discussed in relation to the idiosyncratic closure processes of the four shipyards.

Table 4 summarizes the treatment effects and closure processes for each shipyard and presents the Spearman correlations across industries for three variables: the share of shipyard workers who found new jobs in the industry, the industry's share of total employment in the shipyard's FUR, and the relatedness of shipbuilding to the industry.

The top ten industries in terms of re-employing redundant shipyard workers are shown for the time of closure for each shipyard in Table 5 (see appendix). The table also shows the sizes of these industries as shares of full-time equivalent (FTE) employment in the FUR and skill

relatedness to shipbuilding. Many of these industries are closely related to shipbuilding, but there are a number of noticeable exceptions, such as general public service activities, consulting engineers and architects, and general contractors. Some of the flows that cannot be explained by relatedness (e.g., the flow to "manufacture of tiles, bricks, cement, and concrete" in Aalborg's case) can be explained by the industry being relatively dominant in the regional industry structure. The regional industry structure clearly affects the flows, as expected in hypothesis 2.

[Table 4: Summary of cases]

When Aalborg Værft closed down, the involvement of the owner and local public and government organizations helped workers find new jobs in which their skills could be reapplied. Clark and Wrigley (1997) argued that management plays an important role in the exit process. However, management's actions also affect the extent of skill destruction for the displaced workers. Consequently, Aalborg Værft has the largest share of workers who found jobs at spinoffs and the highest rate of direct mobility (cf. Table 2). Thus, a relatively large number of its workers experienced the positive treatment effect found for spinoffs. When Danyard Frederikshavn closed down later, a similar closure process resulted in stronger effects: despite not being able to allocate a particularly large share of workers to spinoffs or direct mobility, the effect of spinoffs was markedly higher than in the other cases, and it is the only case where a significant effect of direct mobility could be identified. The generally positive effect of finding a job at a spinoff is in line with the arguments of Buenstorf and Fornahl (2009) and Boschma and Frenken (2011), and the results of Eich-Bohn and Hassink (2005).

In contrast, the owner of Nakskov Skibsværft did not participate in the closing down process and the shipyard was located in a peripheral low growth region. Still, the treatment effects are similar to the Aalborg case: Reallocation of skills is observed in the instances where the new job was at

a spinoff company or in a related industry. However, looking at Table 2, it can be seen that the shares of workers finding a job at a spinoff or in a related industry are smaller for the Nakskov case. A relatively high share of workers left Nakskov after leaving the shipyard, but there is nevertheless no effect of moving away on wage growth. Nakskov Skibsværft did have a product portfolio of specialized ships and had diversified into other areas, like Aalborg and Danyard, and the share of workers finding new jobs at spinoffs was higher than at Danyard, but it seemed that the lack of involvement from the conglomerate's ownership meant that these spinoffs were unable to reallocate skills to the same extent.

The cases of Aalborg Værft and B&W shared practically no commonalities in their closure processes, but their local regional characteristics were similar, as both were located in growing urban regions with thick labor markets and many educational institutions. For these two cases, the rank correlations across industries between the flow of former shipyard workers and regional industry employment, and between the flow and relatedness of shipbuilding skills to the local industries, are both positive and statistically significant. The two correlations are of similar magnitude for each shipyard. These findings mean that the workers find jobs in industries that are co-located with the shipyards and that they find jobs in related industries. For the two cases in relatively stagnant peripheral regions with thin labor markets, Nakskov and Danyard, the correlations are also positive and significant, but the correlation with relatedness tends to have the highest magnitude. These results imply that workers tend to find jobs in related industries rather than just in those that happen to be co-located. This implication is in agreement with the expectation inferred from Neffke, Henning, and Boschma (2011) and supports hypothesis 2.

Additionally, the rank correlation of relatedness and regional industry employment is zero for all cases, except for B&W, where it is negative. This finding means that the regions did not

absolutely specialize in shipbuilding. These correlations do not suggest that the closure process affects the degree to which former workers' new jobs are in skill-related industries. However, the share of workers who find a job in a related industry is highest for Aalborg and particularly low for B&W (cf. Table 2), suggesting that the idiosyncrasies of the processes and regions (especially the shipyard owners' active involvement) did help the workers find more related jobs and thus avoid skill destruction.

7 CONCLUSION

This paper makes a twofold contribution to our understanding of the consequences of large company closures. Firstly, it adds to the general literature on company and plant closure by explicitly taking the employees' perspective, and secondly, it adds particularly to our understanding of the consequences of large company closures on localized knowledge flows.

Other studies on displaced workers from declining industries or failing firms often indicate that most workers find new jobs fairly quickly, which is contrary to the fear in public media and among policymakers that these events would lead to massive and prolonged unemployment. Our study also finds that 18-48 percent of workers secure new jobs without any unemployment spell (excluding the 2-5 percent that enter education), while most workers (82–91 percent) find new jobs eventually. Since many workers also retire, the effect on regional unemployment rates seems to be only temporary, which challenges the findings of Hassink and Shin (2005). However, our results also show that finding a new job in an unrelated industry leads to skill destruction, which is likely to create large differences in lifetime income.

Theories on regional evolution argue that the regional industry structure diversifies into skill-related industries over time. However, these studies tend to overlook the creative destruction of

firms and skills. The literature on restructuring old industrial regions tends to look at the overall regional economy (e.g., Tödtling and Trippl, 2004), while the plant closure literature (e.g., Tomaney, Pike, and Cornford, 1999) focuses on the effects on the regional labor market or whether displaced workers find new jobs. Therefore, little attention has been given to the destruction and reallocation of skills following forced labor mobility from the closure of large firms and how regional industry relatedness might affect outcomes. Our analyses of the laid-off shipyard workers suggest that the movement of workers to related industries leads to less skill destruction. The effect is strong, ranging from 11 to 14 percentage points in additional wage growth. This result is found for all four shipyards, even though they were closed down through different processes, were located in different regions, and closed down in different years.

The finding that workers tend to find jobs in related industries, rather than just those that happen to be co-located, has implications for the regional restructuring literature (e.g., Martin and Sunley, 2006; Fingleton, Garretsen, and Martin, 2012).

In all four cases we observe some migration towards larger cities, towards regions that still had shipyards or other related industries and migration towards regions with no related industries. In addition, a lot of the workers that moved to a new municipality moved only a short distance. Hence migration takes many different forms and in general did not play a large role in skill reallocation as only relatively few workers moved and they did not achieve more skill reallocation compared to other workers. The exception is Aalborg where movement resulted in more skill reallocation.

A large company's closure results in challenges for the workers and in skill destruction, but also leaves leeway for policy. Direct mobility into a new job is not necessarily the most effective

treatment for the displaced workers. We find that moving directly into a new job gives a wage growth bonus of at most 5–6 percentage points. A larger effect can be achieved by facilitating job creation in spinoffs (7–12 percentage points) or in skill-related industries (11–14 percentage points). This is consistent with skills being more readily re-employed in skill-related industries and to a lesser extent in spinoffs. Thus, skill-relatedness matters for the labor market and workers. Our results indicate that there is, as expected, a positive effect of new education too. A policy of offering new education to displaced workers from a large company closure in a declining industry is likely to be a sound policy in any instance. While the estimated effects do vary somewhat across shipyards, there is a lot more variation in the number of workers that actually experience the effect in each case. The closure of B&W in central Copenhagen, which offers a large and diverse labor market, could lead to skill reallocation (Puga, 2010), but relatively few workers experienced the positive effect of working in a related industry or for a spinoff. The shipyard's disorganized closure clearly added to the destruction of the displaced workers' skills in the region. Aalborg Værft's closure provides a more successful story because the owner and other regional organizations and policymakers worked together to maintain the healthy parts of the company. This case offers an important lesson for policymaking.

Comparison across the cases revealed that establishing a business park and otherwise encouraging spinoff firms alleviates skill destruction, especially if the former shipyard owner actively takes part. It also revealed that urbanization on its own and, in particular, the presence of skill-related industries in the region alleviate skill destruction.

The research presented in this paper answers some questions about the consequences for workers and their skills when large firms close down, but some areas for future consideration remain: it may be argued that the effects of the treatments studied here are confounding – that combining

treatments results in an effect that is not simply the sum of the individual treatments' effects. Secondly, the reallocation and destruction of skills will also affect the future development of the region. In the long run, shipbuilding more or less disappeared from all Danish regions and, thus, industries depending on shipbuilding disappeared too. However, new industries emerged and it is not clearly understood what role was played, if any, by the reallocation of skills from the declining industries.

8 REFERENCES

Adsersen, Torkil and Niels J. Nielsen. 2005. *Sjak, mestre og skibsbyggeri. Arbejdsliv på B&W 1945-1996*. Copenhagen: Arbejdermuseet.

Andersen, Steen. 1996. "The Closure of Elsinore Shipyard", in E. Wadensjö (ed.), *The Nordic Labour Market in the 1990s*, vol. 2, Amsterdam: Elsevier, pp. 177-191.

Andersen, Steen and Donald W. Storrie. 1996. "A comparison of early exits following the Elsinore and Uddevalla shipyard closures", in E. Wadensjö (ed.), *The Nordic Labour Market in the 1990s*, vol. 2, Amsterdam: Elsevier, pp. 219-225.

Almeida, Paul and Bruce Kogut. 1999. "Localization of Knowledge and the Mobility of Engineers in Regional Networks," *Management Science,* 45(7), 905-917.

Annual Reports from Aalborg Værft 1975-1991, B&W Skibsværft 1995-1996, Danyard Frederikshavn 1990-2000, and Nakskov Skibsværft 1980-1987.

Bailey, David, Caroline Chapain, and Alex de Ruyter. 2012. "Employment Outcomes and Plant Closure in a Post-industrial City: An Analysis of the Labour Market Status of MG Rover Workers Three Years On," *Urban Studies* 49(7), 1595-1612.

Board Protocols from Nakskov Skibsværft 1980-1987, Aalborg Værft 1986-1990, Danyard Frederikshavn 1990-2000, and B&W Skibsværft 1995-1996

Boschma, Ron, Rikard Eriksson, and Urban Lindgreen. 2009. "How does labour mobility affect the performance of plants? The importance of relatedness and geographical proximity," *Journal of Economic Geography*, 9(2), 169-190.

Boschma, Ron and Koen Frenken. 2011. "The emerging empirics of evolutionary economic geography," *Journal of Economic Geography*, 11(2), 295-307.

Boschma, Ron, Asier Minondo, and Mikel Navarro. 2013. "The Emergence of New Industries at the Regional Level in Spain: A Proximity Approach Based on Product Relatedness," *Economic Geography*, 89(1), 29-51.

Brown, Jason P., Dayton M. Lambert, and Raymond J.G.M. Florax. 2013. "The Birth, Death, and Persistence of Firms: Creative Destruction and the Spatial Distribution of U.S. Manufacturing Establishments, 2000-2006," *Economic Geography*, 89(3), 203-226.

Buenstorf, Guido and Dirk Fornahl. 2009. "B2C—bubble to cluster: the dot-com boom, spin-off entrepreneurship, and regional agglomeration," *Journal of Evolutionary Economics*, 19(3), 349-378.

Caliendo, Marco and Sabine Kopeinig. 2008. "Some practical guidance for the implementation of propensity score matching," *Journal of Economic Surveys*, 22(1), 31-72.

Chapain, Caroline and Alan Murie. 2008. "The impact of factory closure on local communities and economies: the case of the MG Rover Longbridge closure in Birmingham," *Policy Studies* 29(3), 305-317.

Christensen, Erik S. 2010. *En værftskrønike. Historien om Frederikshavn Værft fra begyndelsen i 1870.* Frederikshavn: Frederikshavn Maritime Erhvervspark.

Clark, Gordon L. and Neil Wrigley. 1997. "Exit, the firm and sunk costs: reconceptualizing the corporate geography of disinvestment and plant closure," *Progress in Human Geography*, 21(3), 338-358.

Dahl, Michael S. and Olav Sorenson. 2010. "The migration of technical workers," *Journal of Urban Economics,* 67(1), 33-45.

Diamond, Alexis and Jasjeet S. Sekhon. 2013. "Genetic matching for estimating causal effects: A general multivariate matching method for achieving balance in observational studies," *The Review of Economic and Statistics*, 95(3), 932-945.

Eich-Born, Marion and Robert Hassink. 2005. "On the battle between shipbuilding regions in Germany and South Korea," *Environment and Planning A*, 37(4), 635-656.

Essletzbichler, Jürgen. 2015. "Relatedness, Industrial Branching and Technological Cohesion in US Metropolitan Areas," *Regional Studies,* 49(5), 752-766.

Essletzbichler, Jürgen. 2004. "The geography of job creation and destruction in the U.S. manufacturing sector, 1967-1997," *Annals of the Association of American Geographers,* 94(3), 602-619.

Fingleton Bernard, Harry Garretsen, and Ron Martin. 2012. "Recessionary shocks and regional employment: Evidence on the resilience of U.K. regions," *Journal of Regional Science*, 52(1), 109-133.

Gathmann, Christina and Uta Schönberg. 2010. “How general is human capital? A task-based approach,” *Journal of Labor Economics,* 28(1), 1-49.

Hansen, Niels B. 2008. *B&W – Værftet der ikke måtte overleve.* Copenhagen: Forlaget Sohn.

Hassink, Robert. 2010. “Locked in decline? On the role of regional lock-ins in old industrial areas,” in R. Boschma and R. Martin (eds.) *Handbook of Evolutionary Economic Geography,* Cheltenham: Elgar, pp. 450-468.

Hassink, Robert and Dong-Ho Shin. 2005. “The restructuring of old industrial areas in Europe and Asia,” *Environment and Planning A,* 37(4), 571-580.

Hellerstein, Judith K., David Neumark, and Kenneth R. Troske. 1999. “Wages, productivity, and worker characteristics: Evidence from plant-level production functions and wage equations,” *Journal of Labor Economics,* 17(3), 409-446.

Herzog Jr, Henry W., Alan M. Schlottmann. 1995. “Worker displacement and job-search: a regional analysis of structural impediments to reemployment,” *Journal of Regional Science,* 35 (4), 553-577.

Hill, Catherine and Ann Markusen. 2000. “Do Regions Matter? Evidence from Twelve Defense Downsizing Regions.” *Berkeley Planning Journal,* 14(1), 82–103.

Hoetker, Glenn and Rajshree Agarwal. 2007. “Death hurts, but isn’t fatal: The postexit diffusion of knowledge created by innovative companies,” *Academy of Management Journal*, 50(2), 446-469.

Holm, Jacob R. 2016. "*Methodological considerations for a quasi-experimental approach to skill reallocation and destruction*". Aalborg, Denmark: Department of Business and Management, Aalborg University.

Hudson, Ray and David Sadler. 1985. "Communities in Crisis The Social and Political Effects of Steel Closures in France, West Germany, and the United Kingdom," *Urban Affairs Review*, 21(2), 171-186.

Jacobson, Louis S., Robert J. LaLonde, and Daniel G. Sullivan. 1993. "Earnings losses of displaced workers," *The American Economic Review*, 83(4), 685-709.

Lundvall, Bengt-Åke. 2004. "The economics of knowledge and learning," in J. L. Christensen and B-Å Lundvall (eds.), *Product Innovation, Interactive Learning and Economic Performance*, Amsterdam: Elsevier, pp. 21-42.

Malecki, Edward J. 2010. "Everywhere? The geography of knowledge," *Journal of Regional Science* 50(1), 493-513.

Martin, Ron and Peter Sunley. 2006. "Path dependence and regional economic evolution," *Journal of Economic Geography*, 6(4), 395-437.

Maskell, Peter. 1986. *Industriens flugt fra storbyen- årsager og konsekvenser*, Copenhagen: Erhvervsøkonomisk Forlag.

Neal, Derek. 1995. "Industry-Specific Human Capital: Evidence from Displaced Workers," *Journal of Labor Economics*, 13(4), 653-677.

Neffke, Frank, Martin Henning, and Ron Boschma. 2011. “How Do Regions Diversify over Time? Industry Relatedness and the Development of New Growth Paths in Regions,” *Economic Geography*, 87(3), 237-265.

Neffke, Frank and Martin Henning. 2013. “Skill-relatedness and firm diversification,” *Strategic Management Journal*, 34(3), 297-316.

Neffke, Frank, César Hidalgo, Anne Otto, and Antje Weyh. 2013. “Inter-industry labor flows,” Cambridge: Center for International Development, Harvard Kennedy School.

Nelson, Richard R. and Sidney G. Winter. 1982. *An Evolutionary Theory of Economic Change*. Cambridge: Belknap Press/Harvard University Press.

Nielsen, Flemming. 2012. *Byens Værft. Aalborg Værfts historie 1912-2012.* Frederikshavn: Frederikshavn Maritime Erhvervspark.

Nooteboom, Bart. 2000. *Learning and Innovation in Organizations and Economies*. Oxford, U.K.: Oxford University Press.

Ohlsson, Harry and Donald Storrie. 2012. “Long-term effects of public policy for displaced workers in Sweden. Shipyard workers in the west and miners in the north,” *International Journal of Manpower*, 33(5), 514-538.

Olesen, Thomas R. 2012a. “Fugl Føniks? Transformationen af den danske værftsindustri 1975-2012,” Ph.D. dissertation, Institute of History and Civilization, University of Southern Denmark.

Olesen, Thomas R. 2012b. “Lukningen af Nakskov Skibsværft A/S i 1986,” *Erhvervshistorisk Årbog*, 61(2),1-30.

Olesen, Thomas R. 2013. “From Shipbuilding to Alternative Maritime Industry – the closure of Danyard Frederikshavn in 1999,” *Erhvervshistorisk Årbog*, 62(2), 78-96.

Otto, Anne, Rikard Eriksson, and Martin Henning. 2015. “Industrial and geographical mobility of workers exiting the Swedish and West German shipbuilding industry 1970-2000,” paper presented at the 55th ERSA Congress, Lisbon.

Palomeras, Neus and Eduardo Melero. 2010. “Markets for Inventors: Learning-by-Hiring as a Driver of Mobility,” *Management Science*, 56(5), 881-895.

Parent, Daniel. 2000. “Industry-specific capital and the wage profile: Evidence from the national longitudinal survey of youth and the panel study of income dynamics,” *Journal of Labor Economics*, 18(2), 306-323.

Poulsen, René T. and Henrik Sornn-Friese. 2011. “Downfall delayed: Danish shipbuilding and industrial dislocation,” *Business History*, 53(4), 557-582.

Puga, Diego. 2010. “The magnitude and causes of agglomeration economies,” *Journal of Regional Science* 50(1), 203-219.

Rigby, David L. and Jürgen Essletzbichler. 2000. “Impacts of industry mix, technological change, selection and plant entry/exit on regional productivity growth,” *Regional Studies*, 34(4), 333-342.

Schwerdt, Guido. 2011. “Labor turnover before plant closure: "Leaving the sinking ship" vs. "Captain throwing ballast overboard",” *Labour Economics*, 18(1), 93-101.

Sekhon, Jasjeet S. 2011. “Multivariate and propensity score matching software with automated balance optimization: The Matching package for R,” *Journal of Statistical Software*, 42(7), 1-52.

Sofka, Wolfgang, Miguel T. Preto, and Pedro de Faria. 2014. “MNC subsidiary closures: What is the value of employees’ human capital in new jobs?,” *Journal of International Business Studies,* 45(5), 723–750.

Song, Jaeyong, Paul Almeida, and Geraldine Wu. 2003. “Learning-by-hiring: When is mobility more likely to facilitate interfirm knowledge transfer?,” *Management Science,* 49(4), 351-365.

Statistics Denmark. 1991. *Timeløn og arbejdsomfang i den enkelte ansættelse*. Arbejdsnotat 31, Copenhagen: Danmarks Statistik.

Storrie, Donald W. 1996. “The Closure of Uddevalla Shipyard – a Swedish Case Study,” in E. Wadensjö (ed.), *The Nordic Labour Market in the 1990s*, vol. 2, Amsterdam: Elsevier, pp. 193-217.

Stråth, Bo. 1987. *The Politics of De-industrialization – the Contraction of the West European Shipbuilding Industry*. Kent: Croom Helm.

Timmermans, Bram and Ron Boschma. 2014. “The effect of intra- and inter-regional labour mobility on plant performance in Denmark: the significance of related labour inflows,” *Journal of Economic Geography,* 14(2), 289-311.

Tomaney, John, Andy Pike, and James Cornford.1999. “Plant closure and the local economy: The case of Swan Hunter on Tyneside,” *Regional Studies*, 33(5), 401-411.

Tödtling, Franz and Michaela Trippl. 2004. “Like Phoenix from the Ashes? The renewal of clusters in old industrial areas,” *Urban Studies*, 41(5-6), 1175-1195.

Withington, John. 1989. *Shutdown. The Anatomy of a Shipyard Closure*. London: Bedford Square.

TABLE 1: Number of Workers and Percentage of Gross Population

	Nakskov		Aalborg		B&W		Danyard	
Gross population	1,382	100%	4,599	100%	2,043	100%	1,377	100%
Does not return to work	255	18%	431	9%	368	18%	160	12%
Net population	1,086	79%	3,526	77%	1,644	80%	1,183	86%
Available for matching	898	65%	3,249	71%	1,540	75%	1,079	78%

TABLE 2: Descriptive Statistics

	Nakskov	Aalborg	B&W	Danyard
Observations	898	3,249	1,540	1,079
Treatment variables				
New education	3.57%	5.49%	4.68%	2.32%
Spin-off	8.41%	21.36%	0.26%	5.93%
Moved	9.15%	5.88%	10.39%	5.65%
Direct	18.30%	48.23%	26.30%	34.38%
Unrelated	29.35%	14.22%	42.73%	22.80%
Categorical variables				
University edu	0.89%	2.46%	2.01%	1.30%
Secondary edu	24.22%	31.43%	33.57%	31.79%
Female	5.36%	7.88%	4.94%	5.38%
Full time	96.76%	91.51%	92.34%	96.39%
Long tenure	37.28%	31.15%	55.97%	62.47%
Skilled blue	51.33%	51.49%	60.91%	74.14%
Unskilled blue	22.66%	18.84%	16.82%	16.69%
Continuous variables				
Wage growth (outcome)				
Mean	4.62%	4.42%	-9.56%	-10.63%
Std.dev.	29.28%	25.25%	34.26%	29.51%
$Wage^{Shipyard}$				
Mean	18.84	20.96	22.93	22.43
Std.dev.	4.49	6.13	7.88	7.38
Age				
Mean	36.91	35.69	36.38	39.73
Std.dev.	10.07	11.03	10.77	10.01
Experience				
Mean	13.38	12.56	14.33	17.78
Std.dev.	6.42	6.63	8.66	8.57

Shares reported for categorical variables. Wage in year 2000 USD. Experience and age in years.

TABLE 3: Matching Results

		Nakskov			Aalborg			B&W			Danyard		
		Min			Min			Min			Min		
Treatment	M	p	ATT		p	ATT		p	ATT		p	ATT	
Direct	1	.0364	3.14%		.0580	3.91%	***	-	-		.0898	6.60%	***
	2	.0639	4.00%		.0030	4.44%	***	-	-		.1570	4.44%	*
	3	.0260	3.55%		.0000	4.35%	***	.1830	1.64%		.0670	4.92%	**
	4	.0080	5.58%	*	-	-		.1360	1.59%		.0610	5.07%	**
	5	-	-		-	-		.0610	1.58%		-	-	
	6	-	-		-	-		.0060	1.60%		-	-	
Spin-off	2	-	-		.3120	8.10%	***	-	-		.4804	12.16%	***
	3	.4010	6.36%	*	.1460	7.31%	***	-	-		.4149	12.15%	***
	4	.4020	6.98%	**	-	-		-	-		.3870	11.63%	***
	5	.2830	6.12%	*	-	-		-	-		-	-	
	6	.1030	5.77%	*	-	-		-	-		-	-	
	7	.1200	5.99%	*	-	-		-	-		-	-	
	9	.0890	6.85%	**	-	-		-	-		-	-	
	10	.0740	7.01%	**	-	-		-	-		-	-	
Unrelated	1	-	-		-	-		.6548	-13.67%	***	-	-	
	2	.4797	-13.45%	***	.5166	-11.03%	***	.1813	-14.24%	***	.2649	-12.39%	***
	3	.4144	-13.71%	***	.5079	-10.66%	***	.1494	-13.99%	***	.1220	-12.47%	***
	4	-	-		-	-		-	-		.0880	-13.33%	***
Moved	3	.3173	4.09%		.5310	4.21%	**	.5641	3.47%		.2320	-0.45%	
	4	.3580	3.47%		.4210	2.92%		.5300	3.72%		.1420	-0.06%	
	5	.1520	2.85%		.2420	3.29%	*	.3380	2.73%		.1400	-0.32%	
	6	.0330	4.33%		.2450	2.99%		.3610	4.31%		.0690	3.44%	
	7	.0460	3.17%		.1810	3.71%	*	.2540	2.93%		.0700	3.27%	
	8	.0320	2.74%		.1500	3.98%	**	.1840	4.87%		.0560	2.45%	
	10	.0160	4.86%		.0700	4.38%	**	.1190	4.54%		.0110	3.91%	
	12	.0020	2.75%		.0380	3.86%	*	.0720	4.62%		.0040	3.40%	
	14	-	-		-	-		.0250	5.02%		-	-	
NewEdu	1	.0040	29.12%	***	.0890	27.82%	***	.1090	23.55%	**	.1410	13.02%	
	2	.0010	33.98%	***	.0520	28.83%	***	.0060	20.17%	***	.1190	20.33%	*
	3	.0000	25.72%	**	.0000	27.35%	***	.0010	25.36%	***	.0290	22.15%	*
	4	-	-		-	-		-	-		.0260	23.02%	**

M is the ratio of controls to treated observations. Min p is the minimum p-value of the 22 tests for balance. ATT is the percentage point effect on wage growth of the treatment for the treated workers. *: significant at 10%, **: 5%, ***: 1%

TABLE 4: Summary of Cases

	Nakskov	Aalborg	B&W	Danyard
Effect of treatment (positive, negative or no effect):				
Direct			0	**+**
Spinoff	**+**	**+**		**+**
Unrelated	**-**	**-**	**-**	**-**
Moved	0	+	0	0
New education			**+**	**+**
Owned by conglomerate	Yes	Yes	No*	Yes
Business park created	Yes	Yes	No	Yes
Owner participated in business park	No	Yes	(-)	Yes
Spinoffs created by owner/management	Yes	Yes	No	Yes
Product portfolio**	Spec.-Div.	Spec.-Div.	Stdt.	Spec.-Div.
Region	Periphery	City	City	Periphery
Spearman (rank) correlations across industries:				
Flow and Regional employment	**.430**	**.523**	**.383**	**.370**
Flow and Relatedness	**.568**	**.533**	**.386**	**.586**
Regional employment and Relatedness	-.130	-.037	**-.451**	-.109

The "flow" of an industry is the share of former shipyard workers that found a new job in the industry. The "Regional employment" of an industry is the share of total regional employment that the industry accounts for. Correlations in bold are significant at 1%. None other are significant at 10%. n: 79 to 97 industries depending on the number of industries with a flow of zero. *: B&W was owned by a conglomerate, but it did not own much else and thus went bankrupt along with B&W. **: Shipyards are classified according to their product portfolio as either Spec.-Div: Specialized ships, diversified into other areas, or Stdt.: Standardized ships only.

TABLE 5: Regional Industry Structure and Labor Flows

Aalborg Værft, Aalborg Functional Urban Region (FUR)

Rank	Share of redundant shipyard workers (percent)		FTE employment in FUR (percent)	Skill relatedness
1	Building of ships and boats	30.50	1.10	1.00
2	Mfr. of building materials of metal	22.71	2.29	0.82
3	General contractors	3.31	3.68	0.21
4	Consulting engineers and architects	2.82	1.02	0.31
5	Plumbing	2.50	0.91	0.60
6	Mfr. of tiles, bricks, cement and concrete	2.35	2.50	0.30
7	Mfr. of machinery for general purpose	2.27	1.55	0.64
8	Defense, police and administration of justice	2.27	2.86	0.27
9	Mfr. of machinery for industries	2.19	0.86	0.50
10	General public service activities	2.14	9.92	-0.41

Nakskov Skibsværft, Lolland-Falster FUR

Rank	Share of redundant shipyard workers (percent)		FTE employment in FUR (percent)	Skill relatedness
1	Building of ships and boats	11.40	0.57	1.00
2	Mfr. of building materials of metal	11.18	0.95	0.82
3	General public service activities	7.67	10.52	-0.41
4	General contractors	7.45	2.15	0.21
5	Mfr. of other food products	5.54	5.23	0.08
6	Consulting engineers and architects	4.90	0.47	0.31
7	Mfr. of machinery for industries	3.09	0.94	0.50
8	Mfr. of rubber and plastic products	2.66	0.81	0.13
9	Mfr. of marine engines and compressors	2.66	1.42	0.69
10	Plumbing	2.24	0.64	0.60

B&W, Copenhagen FUR

Rank	Share of redundant shipyard workers (percent)		FTE employment in FUR (percent)	Skill relatedness
1	Mfr. of building materials of metal	9.51	0.57	0.83
2	Building of ships and boats	5.34	0.04	1.00
3	General contractors	5.03	1.66	0.36
4	Refuse disposal and similar activities	3.79	0.68	-0.23
5	Install. of electrical wiring and fittings	3.73	1.04	0.53
6	Consulting engineers and architects	3.11	2.25	0.21
7	Mfr. of machinery for general purpose	3.05	0.45	0.50
8	Mfr. of machinery for industries	2.92	0.54	0.41
9	General public service activities	2.73	3.46	-0.74
10	Mfr. of marine engines and compressors	2.49	0.34	0.60

Danyard Frederikshavn, Vendsyssel FUR

Rank	Share of redundant shipyard workers (percent)		FTE employment in FUR (percent)	Skill relatedness
1	Building of ships and boats	25.67	2.55	1.00
2	Install. of electrical wiring and fittings	6.87	1.35	0.66
3	Mfr. of building materials of metal	4.98	0.60	0.83
4	Consulting engineers and architects	4.64	0.56	0.48
5	General contractors	3.00	2.28	0.31
6	Other construction works	3.00	0.36	0.59
7	Mfr. of computers and electric motors	2.92	1.12	0.53
8	Cleaning activities	2.49	0.47	-0.28
9	Mfr. of marine engines and compressors	2.40	1.68	0.54
10	Mfr. of machinery for industries	2.40	0.94	0.64