Special Section

Chapter 7

Trade in Tasks

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*This chapter analyses the task content of goods and services and sheds light on possible structural changes following trade liberalisation. The task content of goods and services is estimated by combining information from the O*Net database on the importance of a set of 41 tasks for a large number of occupations and information on employment by occupation and industry. The study shows that tasks that can be digitised and offshored are often complementary to tasks that cannot. Therefore, the assessment of the offshorability of a job requires that one take into account all tasks being performed. The study finds that import penetration in services has a small, but positive effect on the share of tasks related to getting and processing information being performed in the local economy. In other words, offshoring complements rather than replaces local information processing.*

7.1. Introduction

Division of labour has been an important source of productivity gains since the first human beings engaged in hunting and gathering. Indeed, one of the most striking trends in economic development since pre-historic times is the deepening division of labour all the way from within self-sufficient households to global value chains. The development has taken place in fits and spurts following the opening of new transport routes, innovations in transport and communications technology and innovations in management and work organisation. The most recent turn in this spiral of expanding markets and deepening division of labour is trade in tasks facilitated by the proliferation of the internet and its rapidly growing capacity for information transmission.

A task is an activity that needs to be accomplished within a defined period of time. Production of goods and services consists of a number of individual tasks; the more complex the good or service, the more tasks are involved. As famously observed by Adam Smith when visiting a pin factory, a single worker "not educated to his business" could at best make 20 pins per day. However, with the introduction of division of labour breaking production of pins down to 18 distinct tasks performed by 10 different workers, output per worker per day increased to 4 800 pins, a productivity gain almost beyond imagination.

What, exactly, do workers of different occupations do when putting together a car, a T-shirt or an iPad; when underwriting a cross-border merger, writing a computer program or when preparing a meal? Do for instance machine operators perform the same tasks in the United States, German, Japanese and South African car manufacturing plants? To what extent can the bundle of tasks needed to produce a good or a service be unbundled? Which tasks can be automated and performed by computers or robots? Which tasks can be performed at a distance? Conversely, what holds bundles of tasks together? These are critical questions for understanding the driving forces and labour market implications of trade in tasks. This chapter sheds more light on how structural shifts in the composition of tasks being performed within countries and industries are related to international trade, particularly trade in services. The question as to which forces keep bundles of tasks together has largely been overlooked in the literature hitherto. We show that bringing this aspect into the analysis may change the results substantially.

A new approach to measuring trade in tasks

Measuring trade in tasks is easier said than done since tasks are not a well-defined statistical unit recorded in production and trade statistics. Trade policy analysts have therefore looked for indirect ways of measuring such trade. One approach has been to assess the tradability of jobs based on detailed studies of the job content in different occupations. A job can potentially be offshored if tasks that can easily be codified and digitised feature prominently among the duties performed by the worker. Matching indices of the importance of offshorable tasks by occupation with data on employment by occupation, it was found that between 20 and 29% of all jobs in major economies such as the United States, Canada and Australia could be offshored.[1] Furthermore, these jobs include medium to high-skilled professions that hitherto have been sheltered from international competition. These estimates caused alarm, raising fears that well-paying jobs that had previously been protected from international competition could at best face downward pressure on wages and at worst become trade-displaced.

1. See van Welsum and Vickery (2005), Blinder (2009) and Jensen and Kletzer (2010).

The most detailed information available on the task content of occupations is the Occupational Information Network (O*Net) database for the United States. O*Net is a project on occupational information sponsored by the US Department of Labour. The version of the database we have used covers 855 occupations[2]. We follow previous studies in using the typology of tasks derived from the "O*Net content model" under the category "occupational requirements", which characterises occupations by a set of standardised activities. Our list of 41 tasks reported in Table 7.1 comes from the sub-category "generalised work activities".

Table 7.1. Typology of tasks

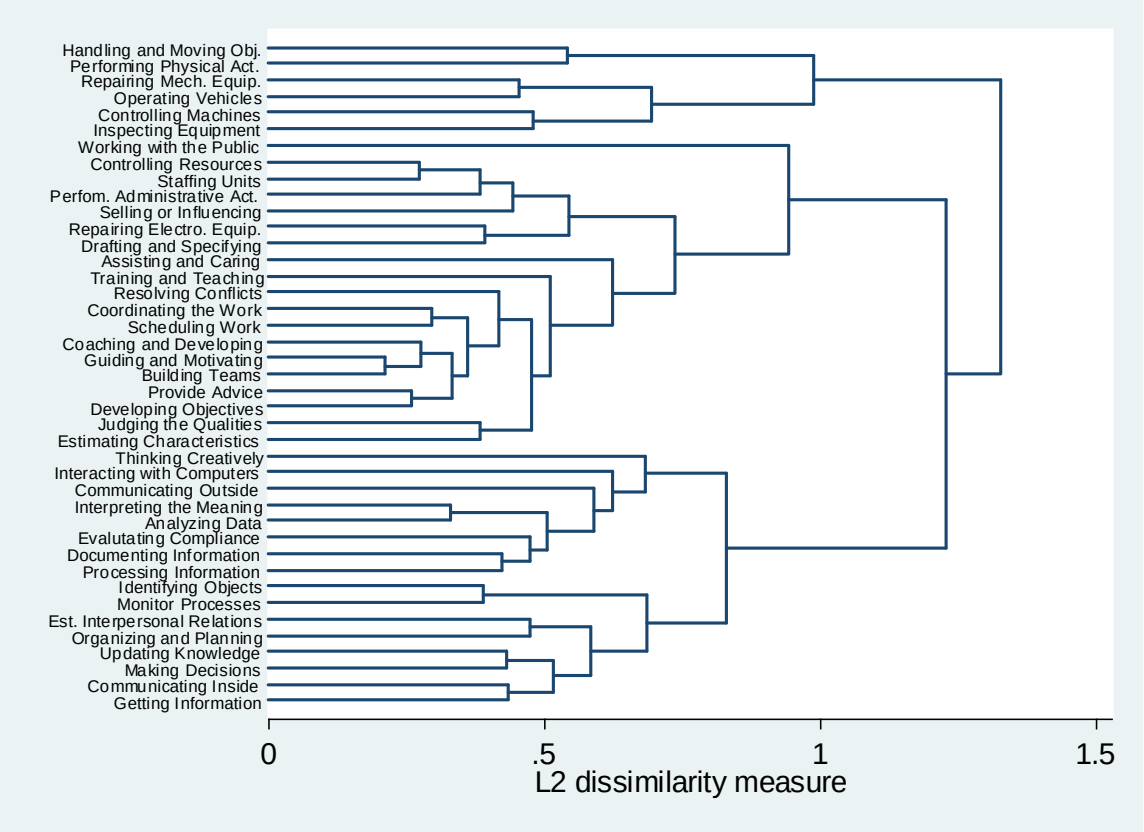
Tasks	ID
1. Getting Information	111
2. Monitor Processes, Materials, or Surroundings	112
3. Identifying Objects, Actions, and Events	121
4. Inspecting Equipment, Structures, or Material	122
5. Estimating the Quantifiable Characteristics of Products, Events, or Information	123
6. Judging the Qualities of Things, Services, or People	211
7. Processing Information	212
8. Evaluating Information to Determine Compliance with Standards	213
9. Analyzing Data or Information	214
10. Making Decisions and Solving Problems	221
11. Thinking Creatively	222
12. Updating and Using Relevant Knowledge	223
13. Developing Objectives and Strategies	224
14. Scheduling Work and Activities	225
15. Organizing, Planning, and Prioritizing Work	226
16. Performing General Physical Activities	311
17. Handling and Moving Objects	312
18. Controlling Machines and Processes	313
19. Operating Vehicles, Mechanized Devices, or Equipment	314
20. Interacting With Computers	321
21. Drafting, Laying Out, and Specifying Technical Devices, Parts, and Equipment	322
22. Repairing and Maintaining Mechanical Equipment	324
23. Repairing and Maintaining Electronic Equipment	325
24. Documenting/Recording Information	326
25. Interpreting the Meaning of Information for Others	411
26. Communicating with Supervisors, Peers, or Subordinates	412
27. Communicating with Persons Outside Organization	413
28. Establishing and Maintaining Interpersonal Relationships	414
29. Assisting and Caring for Others	415
30. Selling or Influencing Others	416
31. Resolving Conflicts and Negotiating with Others	417
32. Performing for or Working Directly with the Public	418
33. Coordinating the Work and Activities of Others	421
34. Developing and Building Teams	422
35. Training and Teaching Others	423
36. Guiding, Directing, and Motivating Subordinates	424
37. Coaching and Developing Others	425
38. Provide Consultation and Advice to Others	426
39. Performing Administrative Activities	431
40. Staffing Organizational Units	432
41. Monitoring and Controlling Resources	433

Source: Based on the O*Net database.

2. We have worked with the O*Net Production database version 15.1.

The 41 tasks described in Table 7.1 are the basic building blocks of occupations and each occupation can be described as a matrix of tasks, telling us the proportion of each task in the occupation under consideration. While previous studies have identified the tradable amongst the 41 tasks and limited the analysis to the importance of these in employment, we take all 41 tasks into account in our analysis. By so doing we are able to study which tasks tend to be performed together across occupations and thus not only possible fragmentation of production but also the forces that keep tasks together, including economies of scope. Thus, while other studies assume that tasks are separable, we make the question of separability a central part of the analysis. A cluster analysis of tasks performed across occupations is a useful tool for assessing bundling of tasks. Figure 7.1 is a so-called dendrogram, which is simply a tree showing how tasks are clustered together statistically.

Figure 7.1. Dendrogram for the task content of occupations



Note: The dendrogram is obtained by applying hierarchical cluster analysis to the tasks by occupation dataset. Euclidian (L2) distance between clusters is calculated with the complete-linkage method.

The tree shows the hierarchy in the cluster analysis; the higher the value on the horizontal axis, the more dissimilar are tasks (in the sense that the same tasks tend not to appear together in occupations). Starting from the right, the two first branches divide the list of tasks (represented on the vertical axis) into two groups. The first group involves tasks related to "handling and moving objects" (312), "performing general physical activities" (311), "repairing and maintaining mechanical equipment" (324), "operating vehicles" (314) and "controlling machines and processes" (313). These tasks are rather manual and the cluster makes sense for all occupations involving manual work or mechanical work. All the other tasks are in a second

cluster. Following the tree from the right to the left, one can see how these other tasks bundled together are further subdivided in sub-groups.

An interesting finding coming out of Figure 7.1 is that some tasks we would not expect to be grouped together are indeed associated in the dataset. For example, "interacting with computers" (321) is in the same cluster as "communicating with persons outside the organization" (413).[3] "Interacting with computers" is also correlated with "processing information" (212) or "analyzing data" (214) as one would expect. But within the same cluster, we also find "interpreting the meaning of information for others" (411). This reveals that "working with computers" and "analysing data" - typically offshorable tasks in the literature - may be bundled with less offshorable activities involving "work with others" or "persons outside the organization".

Another interesting example is "establishing and maintaining interpersonal relationships" (414). Jensen and Kletzer (2010) regard it as negatively related to offshoring because it involves face-to-face contacts. On Figure 7.2, it appears bundled with another group of tasks where we find "getting information" (111), which is positively related to offshorability according to Jensen and Kletzer (2010).[4] The cluster analysis supports our hypothesis that tasks are bundled across occupations and that there may be economies of scope of keeping them together.

We will now calculate the task content of occupations, industries and trade. The first step is to calculate the proportion of tasks in each occupation. Here we follow the earlier literature[5] and calculate the task intensity as a Cobb-Douglas weighted average of two indices derived from the O*Net database: the relative importance of each task (on a scale between 1 and 5) and the level of the task (on a scale between 1 and 7), where the weight of importance is 2/3 and the weight of level 1/3, but including all 41 tasks.[6] The second step is to match data on employment by sector and employment by occupation. To illustrate how this works, consider the activity "interacting with computers" and the sector *construction*. Construction employs architects, engineers, carpenters, plumbers, electricians, drivers, managers and so on, each performing a set of tasks or activities. Interacting with computers is more important in some of these occupations than others. The total intensity of interacting with computers in construction is found by adding the index of its importance for each occupation, weighted by its employment share in the sector. The third step is to use the correspondence between sector classifications and goods and services classifications to establish which sector produces which goods and services and then estimate the task content of goods and services. Finally, having estimated the task content of goods and services, the task content of trade can be computed by combining the estimate of task content of goods and services in the exporting country with export values.[7] Note however that

3. This refers to the part of Figure 7.2 where the tree has 10 branches. The next section will present evidence for these 10 clusters and Table 7.2 provides their description.

4. Jensen and Kletzer (2010), in the same paper, propose to infer offshorability on the basis of geographic concentration in the US economy. We refer here to their use of the O*Net database.

5. Blinder (2009), Jensen and Kletzer (2010) and Firpo *et al*. (2011).

6. The correlation coefficient between the two indices is 0.91. Handel (2010) provides an assessment of the O*Net content model and notes that the two categories are largely redundant.

7. See Lanz *et al*. (2011) for the technical details. The task content of imports should be calculated using the task content of goods and services in the exporting country. This methodology avoids the so-called Leontief paradox, which in the case of trade in tasks arises from a false assumption that the occupational composition of employment by sector is the same across countries. Because of lack of comparable information, one is, however, forced to make the assumption that the task content of occupations is similar across countries.

the methodology sketched here does not distinguish between tasks *embodied in* traded goods and services and tasks performed directly across borders.

7.2. Up to the task: a descriptive analysis of task intensities by industry

This section presents an analysis of the task intensities of industries based on the methodology described above for the United States and the Members of the European Union, the only countries for which sufficient data are available. The data come from the Occupational Employment Statistics (OES) in the case of the United States and from the Labour Force Survey (LFS) in the case of the European Union. While our tasks data are limited to US occupations, we introduce a country dimension in the dataset by matching the task content of occupations with country data on occupations by industry. We use a common industry classification (ISIC Rev. 3) for which we have a correspondence with NAICS industries (US) and NACE industries (EU) but the calculation of the task intensity of industries relies on SOC for the United States and ISCO for the European Union.[8]

Table 7.2 below gives an overview of how industries are associated with a higher intensity for specific tasks. We have grouped the 41 tasks of Table 7.1 into the 10 clusters identified by the cluster analysis represented in Figure 7.1. For each cluster, the table indicates the three industries that are the most intensive in this group of tasks. We have separated the United States and European Union data and kept them in their original industry classification (NACE for the European Union and NAICS for the United States). The US industries are more disaggregated. The purpose of the table is not to compare the two lists (as the average intensity by industry is similar in the United States and the European Union), but rather to have an illustration of industry intensities in tasks at two levels of disaggregation.

Industries that are intensive in physical tasks (cluster 1) are, not surprisingly, manufacturing activities such as leather tanning and dressing or manufacture of wood products. But there are also services that can rely on physical tasks, such as postal services or the work done by domestic staff employed by households. Cluster 2 deals with the use of vehicles and mechanical equipment and we find land transportation or school bus transportation as industries intensive in such tasks. Mining activities also appear in this category. Cluster 3 encompasses tasks related to machines that are intensive in specific manufacturing industries. Tasks involving work with the public (cluster 4) are, on the contrary, in services industries such as retail trade, personal care services or hotels and restaurants. In cluster 5, associated with selling, we find retail trade at the 2-digit level and more specific types of stores at the 4-digit level.

8. The employment surveys in the European Union use the International Standard Classification of Occupations (ISCO) while the United States apply the Standard Occupation Classification (SOC) system. The structure of the two classifications is quite different, but when comparing our calculated task intensities by industry between the European Union and the United States, there is a good correlation with only a few outliers, making us confident that the United States and European Union data can be compared. Another issue is the transportability of job information across countries. Taylor (2007) finds that the task content of occupations is similar in countries as diverse as the United States, New Zealand, China and Hong Kong, China. This suggests that it is reasonable to make the assumption that the task content of occupations is the same across countries.

Table 7.2. Task intensities by industry: Top-3 industries for each cluster of tasks (European Union and United States)

Cluster	Tasks involved	Top 3 EU industries (NACE 2-digit)	Top 3 US industries (NAICS 4-digit)
1 - Physical tasks	Performing General Physical Activities	Tanning and dressing of leather	Seafood Product Preparation and Packaging
	Handling and Moving Objects	Activities of households as employers of domestic staff	Animal Slaughtering and Processing
		Manufacture of wood and of products of wood (except furniture)	Postal Service
2 - Tasks related to mechanical equipment	Operating Vehicles, Mechanized Devices, or Equipme	Mining of coal and lignite; extraction of peat	School and Employee Bus Transportation
	Repairing and Maintaining Mechanical Equipment	Other mining and quarrying	Waste Collection
		Land transport; transport via pipelines	Coal Mining
3 - Tasks related to machines	Inspecting Equipment, Structures, or Material	Manufacture of wood and of products of wood (except furniture)	Footwear Manufacturing
	Controlling Machines and Processes	Mining of coal and lignite; extraction of peat	Apparel Knitting Mills
		Tanning and dressing of leather	Machine Shops; Turned Product; Screw and Bolt Manufacturing
4 - Working with the public	Performing for or Working Directly with the Public	Retail trade	Gasoline Stations
		Other service activities	Beer, Wine, and Liquor Stores
		Hotels and restaurants	Personal Care Services
5 - Selling and controlling	Drafting and Specifying Technical Devices, Parts, and	Retail trade	Jewelry, Luggage, and Leather Goods Stores
	Repairing and Maintaining Electronic Equipment	Activities auxiliary to financial intermediation	Shoe Stores
	Selling or Influencing Others	Sale, maintenance and repair of motor vehicles	Clothing Stores
	Performing Administrative Activities		
	Staffing Organizational Units		
	Monitoring and Controlling Resources		
6 - Working with others	Estimating the Quantifiable Characteristics of Product	Education	Child Day Care Services
	Judging the Qualities of Things, Services, or People	Health and social work	Limited-Service Eating Places
	Developing Objectives and Strategies	Other service activities	Other Residential Care Facilities
	Scheduling Work and Activities		
	Assisting and Caring for Others		
	Resolving Conflicts and Negotiating with Others		
	Coordinating the Work and Activities of Others		
	Developing and Building Teams		
	Training and Teaching Others		
	Guiding, Directing, and Motivating Subordinates		
	Coaching and Developing Others		
	Provide Consultation and Advice to Others		
7 - Thinking creatively	Thinking Creatively	Education	Personal Care Services
		Computer and related activities	Independent Artists, Writers, and Performers
		Recreational, cultural and sporting activities	Performing Arts Companies
8 - Information processing tasks	Processing Information	Insurance and pension funding	Legal Services
	Evaluating Information to Determine Compliance with S	Computer and related activities	Accounting, Tax Preparation, Bookkeeping, and Payroll Services
	Analyzing Data or Information	Activities auxiliary to financial intermediation	Depository Credit Intermediation
	Interacting With Computers		
	Documenting/Recording Information		
	Interpreting the Meaning of Information for Others		
	Communicating with Persons Outside Organization		
9 - Identifying and monitoring	Monitor Processes, Materials, or Surroundings	Activities of households as employers of domestic staff	School and Employee Bus Transportation
	Identifying Objects, Actions, and Events	Land transport; transport via pipelines	Other Pipeline Transportation
		Manufacture of food products and beverages	Inland Water Transportation
10 - Getting information and communicating	Getting Information	Activities auxiliary to financial intermediation	Legal Services
	Making Decisions and Solving Problems	Insurance and pension funding	Agents and Managers for Artists and Other Public Figures
	Updating and Using Relevant Knowledge	Financial intermediation	Accounting, Tax Preparation, Bookkeeping, and Payroll Services
	Organizing, Planning, and Prioritizing Work		
	Communicating with Supervisors, Peers, or Subordinates		
	Establishing and Maintaining Interpersonal Relationships		

Cluster 6 is a broad category of tasks that have in common working with others. This is, therefore, the category of education, health and other service activities. Thinking creatively is a cluster by itself where education, recreational and cultural services are found. At a more disaggregated level, the industry of artists and performers makes an intensive use of such tasks. Cluster 8 includes information processing tasks that are often regarded as highly offshorable. Industries intensive in such tasks are insurance, financial intermediation and computer and related activities. Identifying and monitoring (cluster 9) is interesting because it appears more cross-cutting in terms of the industries involved. Most of them are related to transportation, but the manufacturing of food products and beverages is also an industry where monitoring processes are important. Lastly, cluster 10 concerns tasks aimed at getting information and communicating with others. Insurance and financial intermediation are the industries intensive in such tasks, as well as professional services (legal services and accounting), when looking at a more disaggregated level.

7.3. How are changes in task content of production related to international trade?

As noted, trade in tasks can only be measured indirectly. Trade is, however, most important for its impact on employment, income and structural changes. This section analyses first, the extent to which the task content of a country's production differs from the task content of its net exports for EU Members and the United States. Next, the extent to which the task content of local production varies systematically with import penetration is explored.

Figure 7.2 shows the contribution to total output by cluster of tasks and country in 2000. The clusters that account for the largest contribution in all countries are the "getting information and communicating" (cluster 10), "information processing tasks" (cluster 8) and "working with others" (cluster 6). It is recalled that cluster 10 contains "getting information", which other studies have considered one of the most tradable tasks, but also "establishing and maintaining interpersonal relationships" and "making decisions and solving problems", two tasks that are considered among the least tradable by other studies. Cluster 8 contains a number of information processing and handling tasks considered to be highly tradable by other studies, while cluster 6 contains many of the least tradable tasks.

Given the relative importance of clusters 10, 8 and 6, it is useful to focus on these three in the following assessment. Table 7.3 reports the respective task content of output and exports of countries for the years 2000 and 2008. There are only small changes in the task content of output from 2000 to 2008. It is also notable that the task content of exports is quite similar to the task content of production. For instance the share of "information processing tasks" varies from 17.6% of the total in Estonia and the Slovak Republic to 23% in Luxembourg in 2008. The content of this task embodied in exports is slightly lower than that embodied in output in all countries included, except Switzerland – where it is slightly higher – and the Netherlands and Luxembourg – where it is the same. The largest difference between the task content of output and exports for this task is found in the United States (18.6% versus 17%).

A higher task content of exports than output suggests comparative advantage in sectors using the task intensively. The sectors that use information processing tasks most intensively are insurance and pension funding, computer and related services and services auxiliary to financial intermediation (see Table 7.2 above). These are among the sectors in which Luxembourg and Switzerland feature the most prominently, and the finding is reassuring as far as the methodology is concerned. It is, however, important to bear in mind that the countries included in the analysis are quite similar in terms of GDP per capita and factor endowments, and that a broader sample of countries would probably exhibit larger differences between task content of trade and production.

Can anything be said about the relationship between the relative intensity of these three tasks clusters and exposure to international trade? To explore this question, the shares were regressed on import penetration of goods and services respectively, controlling for market size (represented by the natural logarithm of country output) and economic development (represented by the natural logarithm of country output per worker). Table 7.4 shows the regressions results for the three clusters "working with others", "information processing", "getting information and communicating". As the sample size is small, results should be interpreted with a large amount of caution.

Figure 7.2. Task content of output (2000)

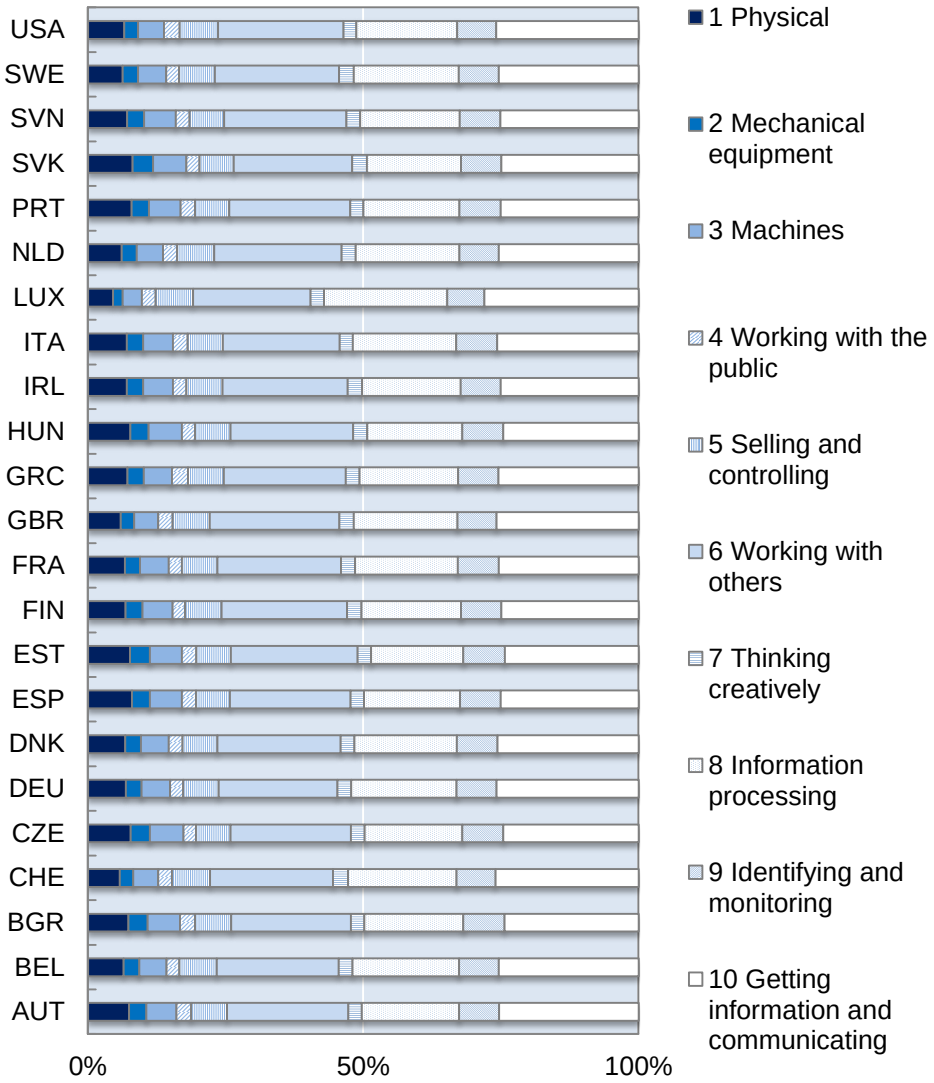


Table 7.3. Relative shares of three selected task clusters in output and exports (%)

	6. Working with others				8. Information processing				10. Getting information and communicating			
	2000		2008		2000		2008		2000		2008	
Country	output	exports	output	exports	output	exports	output	exports	output	exports	output	exports
Austria	22.1	21.3	22.0	21.5	17.6	16.8	18.5	17.5	25.3	24.6	25.6	24.8
Belgium	22.1	21.7	22.4	21.8	19.4	18.7	19.6	19.3	25.5	23.9	26.0	25.2
Bulgaria	21.8	24.9	..	..	17.9	12.6	..	..	24.4	24.6	..	..
Switzerland	22.3	21.6	21.9	21.0	19.7	20.1	19.9	20.2	26.0	25.8	26.2	25.8
Czech Republic	21.8	21.3	21.8	21.0	17.7	16.6	18.4	17.5	24.5	23.8	24.8	24.0
Germany	21.6	21.0	21.7	21.2	19.1	18.2	19.3	18.6	25.8	24.6	25.8	24.7
Denmark	22.3	21.6	22.5	21.7	18.6	17.6	19.0	18.5	25.6	24.6	25.7	25.0
Spain	22.0	21.5	..	..	17.4	16.1	..	..	25.0	24.4	..	..
Estonia	23.0	22.5	23.1	22.8	16.8	15.6	17.6	16.4	24.3	23.7	24.6	23.6
Finland	22.8	22.0	23.1	22.4	18.1	17.9	18.3	18.5	24.9	24.2	24.9	24.3
France	22.5	21.5	22.7	21.8	18.6	18.1	18.9	18.7	25.4	24.5	25.4	24.5
United Kingdom	23.6	22.8	..	..	18.9	18.8	..	..	25.8	25.2	..	..
Greece	22.2	22.3	22.4	21.9	17.9	16.2	18.0	17.0	25.5	24.9	25.5	25.1
Hungary	22.3	21.5	22.5	21.6	17.3	15.7	17.8	16.6	24.6	23.7	24.8	23.8
Ireland	22.7	21.8	..	..	17.9	18.6	..	..	25.1	24.8	..	..
Italy	21.2	20.8	21.6	20.9	18.7	17.2	18.6	17.6	25.7	24.6	25.5	24.4
Luxembourg	21.3	21.2	21.7	21.5	22.4	22.5	23.0	23.0	28.0	27.9	28.0	27.9
Netherlands	23.1	22.5	23.3	22.6	18.9	18.2	19.2	19.2	25.4	24.4	25.4	24.7
Portugal	22.0	21.7	..	..	17.4	15.5	..	..	25.1	24.1	..	..
Slovak Republic	21.5	21.1	21.7	20.9	17.1	16.5	17.6	16.5	24.9	23.6	24.6	23.6
Slovenia	22.2	21.5	22.2	21.5	18.1	16.6	18.3	17.1	25.1	24.0	25.2	24.1
Sweden	22.5	21.3	..	..	19.1	18.5	..	..	25.5	24.6	..	..
USA	22.8	22.5	22.7	22.2	18.3	16.7	18.6	17.0	25.9	24.5	25.7	24.4
Sample average	**22.2**	**21.8**	**22.3**	**21.7**	**18.4**	**17.4**	**18.9**	**18.2**	**25.4**	**24.6**	**25.5**	**24.7**

Table 7.4. Regression analysis: relationship between the output share of task clusters at the country level and import penetration

	6. Working with others	8. Information processing tasks	10. Getting information and communicating
Import penetration: goods	0.013	0.003	-0.011
	(0.017)	(0.018)	(0.011)
Import penetration: services	-0.034	0.119***	0.083***
	(0.024)	(0.024)	(0.015)
Output	0	0.001	0.001*
	(0.001)	(0.001)	(0.001)
Output per worker	0.003	0.009***	0.004**
	(0.003)	(0.003)	(0.002)
Year dummy: 2008	-0.002	-0.004	-0.003*
	(0.003)	(0.003)	(0.002)
Constant	0.196***	0.045	0.178***
	(0.028)	(0.028)	(0.018)
R-squared	0.075	0.793	0.789
Number of observations	38	38	38

None of the three clusters is significantly correlated with import penetration of goods. On the other hand, the shares of the clusters "information processing" and "getting information and communicating" are both significantly and positively correlated to import penetration of services. These two clusters are key for financial services and computer services and results indicate that tasks related to getting and processing information are complementary to services imports. Interestingly, variation in the share of cluster 6 "working with others" across countries appears not to be affected by any of the variables included in the analysis and the explanatory power of the regression is quite low. The variation across countries is also quite small in our sample, suggesting that "working with others", which is most important in sectors such as health and education, is unaffected by trade. The shift in the task composition towards cluster 10 is not surprising, since other studies have also found that import competition has this effect in some of the countries included in our sample. Also the shift towards cluster 8 is in line with a recent study from the United States (Crinò, 2010), but it is nevertheless surprising that import competition from services *increases* the share of information processing tasks in the economy.

7.4. Trade in tasks and structural changes: concluding remarks

This study has emphasised the importance of taking into account both the forces that contribute to unbundling and codification of tasks and the forces that keep tasks together when analysing the potential for trade in tasks. The productivity gains from fragmenting production into simple tasks were understood already centuries ago, famously described in Adam Smith's pin factory and developed further in the scientific management or Taylorism theory which was implemented for instance in Ford's car manufacturing plants, allowing mass production of affordable cars. However, when moving away from mass production of standard products to more sophisticated and differentiated products, Taylorism gave way to Toyotism, which was characterised by multi-tasked, multi-skilled workers working in teams. This way of organising production was considered better suited for an environment in which innovation and problem solving at source are important. Essentially, this study asks whether and to what extent the pendulum is swinging back towards Taylorism with the opening up to the possibility of trade in tasks.

We find that tasks tend to be clustered across occupations suggesting that there may be important economies of scope and synergies in keeping them together – and transaction and coordination costs in unbundling tasks. Econometric results suggest that the tasks embodied in services imports are complementary to tasks related to information gathering and processing performed in the home economy. Thus, trade in services is associated with shifts in the task content of domestic production towards information-intensive tasks at the expense of manual tasks in the United States and the European Union, although the magnitude of the effect is relatively small.

A possible explanation of the apparent complementarity between imported services and information-intensive tasks in OECD countries is that bundles of tasks or entire functions rather than individual tasks are outsourced and offshored. Functions that are typically outsourced include computer software development and maintenance, human resources, accounting and office cleaning, among others. But as more and more firms outsource these, a market is created for specialised suppliers of these services. What are non-core functions for some companies become the core of other companies, and the latter may innovate and transform these functions into a new industry. Computer services are one example, but even office cleaning has followed this path. In the past, most firms employed their own cleaning personnel who cleaned offices with water, soap, a mop and a vacuum cleaner. Specialised office cleaning firms, in contrast, enter the offices with an arsenal of specialised tools, machines and chemicals, providing

cleaning and environmental services – and employment opportunities for a broad range of occupations, including engineers and managers. Fragmentation of production is therefore not equivalent to fragmentation of jobs.

To conclude, trade in tasks is likely to have a similar impact as trade in other intermediate inputs – it improves productivity and induces shifts within firms and sectors in a similar way as technical change does, and will take place when such gains outweigh the cost of unbundling the tasks. The magnitude of structural shifts is difficult to assess, but the fear of massive job losses due to a surge in offshoring of individual tasks is probably overblown. More detailed analysis is necessary before any firm conclusions and policy implications can be drawn.

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Special Section

Chapter 8

Heterogeneous Migration and Offshoring Costs: Evidence on Spillover Effects*

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The focus of this chapter is on the relation between migration and offshoring. In particular, we are interested in "spillover effects" of migration and offshoring policies in a framework with multiple origin and multiple destination countries. There are two types of spillover effects that are particularly relevant from a policy perspective. First, what we define "domestic spillover effects", namely the effect on a change in the migration (offshoring) costs from a given sending country to a given receiving country on offshoring (migration). Second, what we define "direct international spillover effects", namely the cross-country impact of migration (offshoring) costs on migration (offshoring) employment. We find evidence that domestic spillover effects are empirically relevant. The policy implication is that a host government can influence (in particular, reduce) the number of migrant workers not only by acting directly on its migration policy, but also indirectly, by providing incentives for firms to source labor abroad via offshoring. This is especially relevant in light of the stylised fact that individual attitudes are more favourable towards trade than towards migration. Conversely, we find no evidence of direct international spillover effects. The fact that migration between a given origin country and a given destination country is not affected by the cost of migrating from other origin countries, but only by own migration costs, produces a second relevant policy implication: de jure discriminatory migration policies need not be de facto discriminatory.

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* This chapter builds on Beverelli *et al.* (2011). Gianluca Orefice was affiliated with the World Trade Organization in the early phases of this research project. The views presented here are those of the authors and do not reflect those of the institutions they are affiliated with. In particular, they are not meant to represent the positions or opinions of the WTO and its Members and are without prejudice to Members' rights and obligations under the WTO.

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8.1. Introduction

The reduction in the costs of relocating production activities abroad, and the increasing availability of low-wage migrant workers[1] in industrialised countries, allow firms to engage in offshoring or to hire immigrant workers when it is profitable to do so.[2] Given the common perception of negative effects of both migration (in terms of reallocation of jobs) and offshoring (in terms of relocation of production) on native employment, the labour market consequences of these two phenomena have been hotly debated in academia and public discussion.[3]

This chapter sets aside the effects on native employment, to focus on the relation between migration and offshoring. We discuss and empirically test the theoretical implications of a three-country model that features heterogeneous migration and offshoring costs. In particular, we are interested in "spillover effects" of migration and offshoring policies in a framework with multiple origin and multiple destination countries. There are two types of spillover effects that are particularly relevant from a policy perspective. First, what we define as "domestic spillover effects", namely the effect of a change in the migration (offshoring) costs from a given sending country to a given receiving country on offshoring (migration).[4] Second, what we define "direct international spillover effects", namely the cross-country impact of migration (offshoring) costs on migration (offshoring) employment.

The interest in domestic spillover effects is based on the stylised fact that individuals tend to be more pro-trade than pro-immigration (Mayda, 2008). Such differences in public opinion towards trade and immigration are reflected in policy outcomes, with immigration being much more restricted than trade. If domestic spillover effects are relevant, a host government can influence (in particular, reduce) the number of migrant workers not only by acting directly on its migration policy, but also indirectly, by providing incentives for firms to source labour abroad via offshoring.

The interest in direct international spillover effects, in turn, stems from another stylised fact concerning attitudes towards migration, namely that the public in host countries is more favourable to migration from certain sending countries than others. In particular, it has been shown that perceived cultural differences between immigrant and native born population are

1. Recent empirical evidence (Antecol *et al.*, 2003; Butcher and Di Nardo, 2002; Chiswick *et al.*, 2008) shows that immigrants earn a lower wage than native workers, after controlling for workers' characteristics.

2. Offshoring here is defined as the relocation of production processes abroad, leading to trade in intermediate goods across borders.

3. Offshoring is often perceived as a simple relocation of jobs abroad, reducing native employment. In fact, Görg and Hanley (2005), Amiti and Wei (2009) and Crinò (2010) find a mild negative effect of offshoring on domestic employment. But if the relocation of jobs results in a business increasing productivity (or innovation) – a result shown by Amiti and Wei (2009), Görg *et al.* (2008) and Görg and Hanley (2011) – sales can expand, increasing employment (Hijzen and Swaim, 2007). Similarly, migration has been considered for a long time as detrimental for native employment because of substitutability between native workers and migrants (Borjas, 2003; Aydemir and Borjas, 2006; Borjas *et al.*, 2008). But recently, some empirical evidence has reversed this conclusion arguing that migrant and native workers might be imperfect substitutes (D'Amuri *et al.*, 2010; Ottaviano and Peri, 2012) and a productivity gain in using immigrants in production could offset the direct negative effect on native employment (Peri, 2012).

4. Throughout the chapter, we refer to "origin" as a country that sends migrants abroad and receives offshoring activities, and to "destination" as a country that receives migrants and sends offshoring activities abroad.

among the main drivers of public resistance to immigration.[5] Moreover, ethnicity matters when it comes to attitudes, as shown by a large body of sociological research. As a consequence, the public (and representative governments) may prefer migration from culturally close or ethnically similar countries, at the expense of migration from culturally distant or ethnically dissimilar ones. For instance, Ford (2011) has shown that the British public is consistently more opposed to migrants from the "Indian sub-continent" (India, Pakistan and Bangladesh) and from the Caribbean, relative to migrants from Europe and Australia. International spillovers effects can answer the policy question of whether discriminatory migration policies (that is, policies that apply unequal treatment to migrants, depending on their country of origin) are effective in attracting relative more migration from most desired origin countries.

In the empirical application, we find evidence that domestic spillover effects are relevant. The fact that migration is positively affected by offshoring costs has an interesting policy implication: a host county can impact migration from a sending country by reducing the cost of offshoring to the same country. This can be relevant for governments that have their hands tied on migration policy (for instance, because of participation to international agreements on migration), and would like to discourage migration.

Moreover, we find no evidence of international domestic spillover effects. The fact that migration between a given origin country and a given destination country is not affected by the cost of migrating from other origin countries, but only by own migration costs, produces a second relevant policy implication: *de jure* discriminatory migration policies need not be *de facto* discriminatory.

The reminder of the chapter is organised as follows. The next section presents a brief overview of the theoretical model developed by Beverelli *et al.* (2011) and its predictions. Section 8.3 describes the empirical approach and the results. Section 8.4 concludes.

8.2. Theoretical predictions

This section sketches a three-country model of offshoring and migration that yields testable implications on direct effects, domestic spillover effects and international spillover effects of offshoring and migration costs.[6] The model consists of a small open economy, denoted as country *d*, and two other countries, denoted as country *i* and country *j*, which are recipient of offshoring (i.e. firms from *d* offshore some production activities in *i* or *j*) and sending of migrant workers to *d*.

Firms from country *d* produce a final consumption good *Y* using labour. The labour input is an aggregate of a large number of tasks *k*. Tasks, which are ordered on a [0, 1] continuum by increasing level of complexity, can be performed by three types of workers: natives from country *d*; immigrants and offshore workers from foreign countries *i* and *j*. Migrant and offshore workers from countries *i* and *j* are assumed to have the same productivity in the country of

5. Ivarsflaten (2005) and Sides and Citrin (2007) provide evidence that a preference for cultural unity is the strongest predictor of hostility to immigration in a wide range of European societies. The PEW Global Attitudes Report (2007) argues that opinions about immigration are closely linked to perceptions about threats to a country's culture. In 46 of 47 surveyed countries, those who favor stricter immigration controls are also more likely to believe their way of life needs to be protected against foreign influence. Importantly, such preferences need not be related to economic factors. In a pioneering experimental study mentioned by Ford (2011), Sniderman *et al.* (2004) have demonstrated that Dutch hostility to immigrants is greatly magnified simply by describing the migrant group in cultural rather than economic terms.

6. The reader interested in technical details can find them in Beverelli *et al.* (2011).

origin. This implies that the wage rate in the two countries is the same. However, there are migration and offshoring costs that are task- and country-specific. Firms from country *d* decide the allocation of tasks along the continuum based on cost-minimisation.[7]

To make sure that at least a task is assigned to native workers, cost functions are such that sufficiently high-end tasks will be performed by native workers. To address the point of how low- and medium-end tasks are allocated, we rely on the empirical results of Ottaviano *et al.* (2010), who find that easy tasks are covered by migrant workers rather than offshored. We therefore rule out configurations in which low-end tasks are offshored, leaving two possible orderings of tasks, respectively denoted as "ordering 1" and "ordering 2". In the first ordering, it is assumed that offshore workers, independently of whether they are from country *i* or from country *j*, have lower cost of performing more complex tasks than migrant workers. Intuitively, offshoring and migration costs along the task continuum are more determined by workers' characteristics than by countries' characteristics. In the second ordering, workers from country *j*, independently of whether they are migrant or offshore, have lower cost of performing more complex tasks than workers from country *i*. In this case, offshoring and migration costs along the task continuum are more determined by countries' characteristics than by workers' characteristics.

Accordingly, under ordering 1 the sequence of tasks is as follows: $Mi < Mj < Oi < Oj < N$, where M stands for migrants, O stands for offshored workers and N stands for natives. Under ordering 2, the sequence is $Mi < Oi < Mj < Oj < N$. For both models, it is possible to derive testable predictions on the effect of migration and offshoring costs on the employment levels of migrant workers and offshored workers. Such predictions are summarised in Table 8.1.

First, we ask how migration costs from country *i* affect the number of migrants from country *i* and how offshoring costs to country *i* affect the number of offshore workers in country *i*. As one would expect, these *direct effects* are negative under both orderings of tasks.

Second, we ask whether there is an effect of offshoring costs on the own number of migrants and of migration costs on the own number of offshore workers. These *domestic spillover* effects are only present in ordering 2, where, as one would expect, they are positive. A reduction in migration (offshoring) costs not only reduces migration (offshoring), as per direct effects, but also acts across policies.

Third, we ask whether there are cross-country effects of migration and offshoring costs (*international spillover* effects). Such spillover effects can be within-policy (direct effects) or across policies (indirect effects). As shown in Table 8.1, orderings 1 and 2 yield different predictions on direct international spillover effects and the same predictions on indirect effects. The former are predicted to be positive only in ordering 1. The latter are predicted to be null for offshoring costs and positive for migration costs.

7. It should be noted that in the model home firms are assumed to be able to discriminate between natives and immigrants, offering a lower wage per unit of labor to migrants than to native workers. As explained in the introduction, empirical evidence largely supports the idea that immigrants earn a lower wage than native workers, after controlling for workers' characteristics. This is not to claim that immigrants do not exert any downward pressure on wages of native workers, an issue that is still hotly debated in the literature, but that is left aside in this chapter.

Table 8.1. Testable predictions

Type of effect	Description: Impact of…	Sign	
		Ordering 1	Ordering 2
Direct	• Own migration costs on the number of migrants	–	–
	• Own offshoring costs on the number of offshore workers	–	–
Domestic spillover	• Own offshoring costs on the number of migrants	0	+
	• Own migration costs on the number of offshore workers	0	+
International spillover (direct)	• *j*'s migration costs on *i*'s number of migrants	+	0
	• *j*'s offshoring costs on *i*'s number of offshore workers	+	0
International spillover (indirect)	• *j*'s offshoring costs on *i*'s number of migrants	0	0
	• *j*'s migration costs on *i*'s number of offshore workers	+	+

8.3. Empirical evidence

To test the implications of the model, we estimate the following baseline regression equations, respectively a "migration equation" and an "offshoring equation":

$$\ln (NM)_{dit} = \alpha + \eta_t + x'_{dijt}\gamma + \varepsilon_{dijt} \quad (1)$$

$$\ln (NO)_{dit} = \alpha + \eta_t + x'_{dijt}\gamma + \mu_{dijt} \quad (2)$$

where *t* indexes time, *d* denotes the destination country (recipient of immigrants and source of offshoring), *i* and *j* respectively denote origin countries *i* and $j \neq i$, γ is a vector of coefficients to be estimated, *x* is a vector of bilateral migration costs *(mc)* and offshoring costs *(oc)*. In particular, *x* includes the cost of migrating from *i* to *d* (mc_i), the cost of offshoring from *d* to *i* (oc_i), the cost of migrating from *j* to *d* (mc_j) and the cost of offshoring from *d* to *j* (oc_j). The dependent variable of the migration equation is the (log of) the number of migrants from *i* to *d*. The dependent variable of the offshoring equation is the (log of) the number of offshore workers from *d* to *i*.[8] The baseline migration and offshoring regressions, that only include time fixed effects η_t, are progressively augmented with destination fixed effects, origin *i* fixed effects and *i-d* pair fixed effects.[9]

The main methodological issue is how to construct migration and offshoring costs for origin country *j*. Following the theoretical model, country *j* should be similar to country *i* in terms of nominal wage rate, and should differ from *i* only in terms of migration and offshoring costs. We

8. The dependent variables of regressions (1) and (2) are expressed as *ln(x+1)* in order not to lose zero observations. The number of zeros in the dataset used for regressions is however small.

9. The inclusion of pair fixed effects largely addresses endogeneity concerns (see Baier and Bergstrand, 2007 for a detailed treatment of this issue).

follow various approaches to construct, for any origin country *i*, a 'fictitious' country *j*. In Table 8.2 below, we report the results of the preferred approach, where we use an average of the explanatory variables (migration and offshoring costs) across all countries *j* that are similar to *i* and more distant from destination country *d* than *i*.[10]

Another challenge is how to measure migration and offshoring costs. As a proxy for bilateral migration costs between *d* and any origin country *o*, we use the negative of the fitted values from a gravity regression that uses the ratio of total bilateral flows of migrants to resident population as a dependent variable. Similarly, we approximate offshoring costs by using the negative of fitted values from a gravity regression that uses bilateral offshoring flows (proxied by trade in parts and components) as dependent variable. In the gravity regressions, we use as explanatory variables geography, differences in labour costs (approximated by differences in GDP per capita), stock of migrants (only in the migration gravity) and stock of FDI (only in the offshoring gravity). We also include variables that capture the effect of policy choices on outcomes. In the migration regression, we include the variable PTA, a dummy equal to one if countries *d* and *o* have signed a preferential trade agreement (PTA) containing provisions on trade in services (GATS mode IV), or provisions on visa and asylum or provisions on labour market regulation. This variable reflects the effect of migration policies (within preferential trade agreements) on migration costs. In the offshoring regression, we include the variable BIT, a dummy equal to one if countries *d* and *o* have signed a bilateral investment treaty. This variable reflects the potential facilitation effect on offshoring of such treaties.

Data

Migration data are from the OECD's International Migration Dataset. We use the stock of foreign-born workers in destination country *d* from origin *o* as a measure of migrant employment. To build the proxy for migration costs, we instead use as dependent variable of the gravity regression the net inflows of foreign workers. As a measure for the number of offshore workers, we use the employment levels by multinationals affiliates from the OECD's Activity of Multinationals Dataset.[11] To build the proxy for offshoring costs, we instead use trade in parts and components from the UN Comtrade dataset.

Gravity-type data used in the gravity regressions, such as bilateral distance, are from the CEPII gravity dataset assembled by Head *et al.* (2010). Finally, data on the presence/content of a preferential trade agreement (PTA) or a bilateral investment treaty (BIT) between country *d* and country *o* used in the gravity regressions are, respectively, from WTO (2011) and from the UNCTAD website.

Results

The core empirical results are presented in Table 8.2.[12] Columns (1) and (2) report the results of migration regressions; columns (3) and (4) report the results of offshoring regressions. The difference between even- and odd-numbered columns is the inclusion of a different set of fixed

10. Other approaches are discussed in Beverelli *et al.* (2011). "Similarity" is defined by the similarity index proposed by Helpman (1987): $Si_{ijt} = 1 - \left(\frac{GDP_i}{GDP_i+GDP_j}\right)^2 - \left(\frac{GDP_j}{GDP_i+GDP_j}\right)^2$.

11. Unfortunately, the data do not allow including offshore employment through arm's length transactions. The authors fully acknowledge this limitation.

12. The reader is referred to Beverelli *et al.* (2011) for a discussion of the robustness of the results under alternative specifications.

effects. We discuss the direct effects, domestic spillover effects and international spillover effects in turn.

We find overwhelming evidence that direct effects are negative. Own migration costs *(mc_i)* reduce own migration and own offshoring costs *(oc_i)* reduce own offshoring. In particular, one standard deviation increase in the cost of migration reduces migrant employment by 2 to 2.8%; while one standard deviation increase in the cost of offshoring deters offshoring from *d* to *i* by 1.6 to 2.6%. These results are in line with economic intuition and with the predictions of models 1 and 2.

The effect of a change in offshoring costs *(oc_i)* on own migration is positive, and significant in the specification with pair fixed effects (column 2). When the cost of offshoring to country *i* increases, this not only reduces offshoring to that country, but has also an indirect dampening effect on migration from that country. This is consistent with the predictions of ordering 2. The effect of a change in migration costs mc_i on own offshoring, however, are not significantly different from zero, as predicted by ordering 1.

Neither the effect of a change in country *j* migration costs mc_j on migration from country *i* nor the effect of a change in country *j* offshoring costs oc_j on offshoring in country *i* are statistically different from zero, in line with the theoretical predictions of ordering 2.

Finally, consider indirect international spillover effects. The effect of a change in country *j* offshoring costs oc_j on migration from country *i* is not statistically different from zero, again in accordance to ordering 2. The effect of a change in country *j* migration costs mc_j on migration from country *i* is instead positive and significant, as predicted by both models.

Overall, we find strong support of negative direct effects of migration and offshoring costs on migration and offshoring, respectively. Domestic spillover effects are positive in the migration regression with pair fixed effects, but absent otherwise. International spillover effects are mostly absent, with the exclusion of positive indirect spillover effects for the offshoring regressions. We discuss the policy implications stemming from these results in the next section.

8.4. Conclusions and policy implications

This chapter has looked at the effects of migration and offshoring costs on employment levels of migrant workers and offshore workers. It has primarily focused on spillover effects of migration and offshoring policies. We have identified two broad types of such effects: domestic and international spillovers. Domestic spillovers refer to the impact of a change in the cost of migration (offshoring) on the number of offshored (migrant) workers. International spillovers act across national borders. They can be direct or indirect. The direct effects can be explained as follows: the number of migrant workers from a sending nation *i* to a destination nation *d* is potentially affected by the cost of migrating from all other nations that send migrants to *d*. The same applies to the number of workers that firms from country *d* employ as offshore labour in country *i*. The indirect effects can act not only across countries, but also across policies. The number of migrant workers from a sending nation *i* to a destination nation *d* is potentially affected by the cost of offshoring to other nations. Likewise, the number of workers that firms from country *d* employ as offshore labour in country *i* is potentially affected by the cost of migrating from other nations into country *d*.

As argued in the introduction, spillover effects are of considerable policy relevance, especially when it comes to the politically sensitive issue of migration. The first broad policy implication of our results derives from the evidence of positive domestic spillover effects. Since migration is positively affected by offshoring costs, a host country can impact migration from a

sending country *j* by reducing the cost of offshoring to the same country. This can be relevant for governments that have their hands tied on migration policy (for instance, because of participation to international agreements on migration, like the Schengen Treaty) and would like to discourage migration for political or other reasons.

The second broad policy conclusion is related to the weak evidence on cross-country direct spillover effects of migration costs. Since migration between a given origin country and a given destination country is not affected by the cost of migrating from other origin countries, but only by own migration costs, *de jure* discriminatory migration policies need not be *de facto* discriminatory.

Table 8.2. Results of migration and offshoring regressions

Country j's migration and offshoring costs constructed using unweighted average of similar countries[a] that are more distant from destination country d *than country* i

	Migration regressions		**Offshoring regressions**	
Model	**(1)**	**(2)[b]**	**(3)**	**(4)[b]**
Dependent variable	***ln(NM)***	***ln(NM)***	***ln(OS)***	***ln(OS)***
mc_i	-2.813***	-2.018**	-0.383	0.557
	(0.605)	(0.875)	(0.375)	(0.756)
mc_j	-0.202	-0.786	0.767*	1.100**
	(0.403)	(0.562)	(0.441)	(0.527)
oc_i	0.318	1.805***	-1.607***	-2.633***
	(0.337)	(0.420)	(0.481)	(0.793)
oc_j	-0.101	0.185	-0.831	-0.227
	(0.198)	(0.196)	(0.612)	(0.471)
Fixed effects				
Period	yes	yes	yes	yes
Destination country	yes	no	yes	no
Country *i*	yes	no	yes	no
Country *i* * Destination	no	yes	no	yes
Observations	2,814	2,814	379	379
R-squared	0.908	0.365	0.828	0.416
Number of id		416		71

Boostrapped and clustered standard errors in parentheses (clustered by countries *i-d* pair).
Coefficient on constant not reported.
*** p < 0.01; ** p < 0.05; * p < 0.1.
[a] Countries *i* and *j* are similar if GDP similarity index $SI_{ij} > 50^{th}$ percentile.
[b] Within estimation (id variable: countries *i-d* pair).

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