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ABSTRACT

Offshoring and Labor Markets

In this paper we survey the recent empirical literature on the effects of offshoring on wage, employment and displacement. We start with an overview of the measurement of offshoring, organizing our discussion around the three key elements of offshoring: that it involves intermediate inputs for production (vs. final goods for consumption); that it involves imported inputs (vs. domestically produced ones); and that the inputs involved could have been produced internally within the same firm. We then briefly discuss the theories of offshoring, and survey the literature that examines the wage effects of offshoring: the wave of studies using industry-level data; the wave using firm-level data; the wave using worker-level data; and the wave using matched worker-firm data. For each wave we highlight the identification strategies used, critically assess its strength and weakness, discuss its connections with theory, and draw out potential policy implications of its findings. Finally we survey the literature that examines how offshoring affects employment and displacement. We highlight the recent development of a novel cohort-based approach that is specifically designed to address selection with displacement, and capable of identifying the overall effects of offshoring, including wage, displacement, and all other types of transition.

JEL Classification: F1, J2, J3, L2

Keywords: offshoring, wages, unemployment

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1. Introduction

This essay discusses the labor market effects of offshoring, drawing on nearly two decades of research employing theory, measurement and econometrics. Much of the early literature focused on understanding two empirical regularities. One, the premium paid to skilled workers was rising worldwide while the relative use of skilled labor was rising both across and within industries. Two, patterns of trade revealed that nations were increasingly specializing in stages of production rather than exchanging final goods for consumption. While classic trade models that emphasize factor-based comparative advantage in final goods were unable to explain these facts, modifications to these models to incorporate offshoring of production offered greater promise.

From these modest beginnings a rich literature has emerged. Theoretical models have gone from relatively simple adaptations of classic theories to incorporate firm-level heterogeneity, scale economies, foreign direct investment, endogenous innovation, agency problems, investment under uncertainty, and much more. Empirical work has gone from estimating relative demands for skill in a cross-section of industries to tracing the wage and employment trajectories of individual workers subject to offshoring shocks. A narrow focus on wages has expanded to include novel explanations for offshoring, and novel labor market consequences of it. Still, much work remains.

Apart from empirical puzzles, many economists care about offshoring because the public is concerned about offshoring. What are those concerns? Media depictions of offshoring almost invariably focus on the negative aspects. Offshoring leads to job loss,

declining middle class wages, and to rising inequality. A Washington Post article in July 2012¹ nicely summarized this concern,

“The debate over outsourcing has been morphing, and today there are growing numbers of people who think that what started as a sensible, globalized extension of sending some work outside a firm to specialized companies may in fact be creating long-term structural unemployment in the United States, hollowing out entire industries.”

These concerns have featured prominently in recent political campaigns. At a rally in Cincinnati, Ohio, on September 17, 2012, President Obama said,

“...my opponent (Mitt Romney)...His experience has been owning companies that were called ‘pioneers’ in the business of outsourcing jobs to countries like China. He made money investing in companies that uprooted from here and went to China. Now, Ohio, you can’t stand up to China when all you’ve done is send them our jobs.”

While the Romney campaign hotly debated this characterization, a shuttered factory makes a useful campaign backdrop precisely because of its salience in the mind of voters. It also obscures the fact that offshoring involves occupations other than factory workers. Media stories increasingly focus on jobs that require higher education. An article in USA Today in December 2012² highlights the offshoring of legal services,

“Since 2005, legal services such as document review and contract drafting increasingly have been offshored, particularly to India ... Indian attorneys do work that in the U.S. is sometimes done by paralegals and at about half the cost...”

¹ “Numbers don’t tell the whole outsourcing story”, by Steven Pearlstein, the Washington Post, July 2, 2012.

² “More U.S. service jobs go overseas; Offshoring is expected to grow”, by Paul Davidson, December 7, 2012, USA Today.

In January 2013 the British newspaper the Guardian reported the story of a top computer programmer (“Bob”) for Verizon:

“...an examination of his workstation revealed hundreds of pdf invoices from a third party contractor/developer in Shenyang. As it turns out, Bob had simply outsourced his own job to a Chinese consulting firm. Bob spent less than one-fifth of his six-figure salary for a Chinese firm to do his job for him...”

While his web-browsing history displayed an all-day diet of Reddit, cat videos, ebay, and Facebook updates, “...his performance review showed that, for several years in a row, Bob had received excellent remarks for his codes which were ‘clean, well-written and submitted in a timely fashion’...”

The analysis of offshoring in the economics literature incorporates many of these perspectives and concerns. But it balances these concerns with a more systematic view of why offshoring occurs, along with assessments of the benefits (to firms, consumers, and even workers) it provides. Offshoring becomes a new expression of the old idea: gains from trade arising from specialization.

Yet clearly, there are many theoretical and empirical questions related to offshoring and labor markets, of both public and professional concern, that remain unanswered. Our goal in this paper is to review what we know but also to highlight what we do not yet know.

What do we mean by offshoring? We next provide a conceptual discussion that distinguishes offshoring from related phenomenon, and then in Section 2 relate this conceptual definition to various approaches at measurement. To be clear, there is no single definition

appearing in the literature and so our statement is intended to capture common, but not universal, usage.

Production of a final good or a service consists of many tasks, which at a very broad level might include research and design, component production and assembly, marketing and distribution. And, of course, within these broad categories one might find further and innumerable subdivisions of tasks. Task production can be disaggregated both geographically (within and across nations) and organizationally (within and across firms). Offshoring is then the process of changing the geographic assignment of the mix of tasks needed to produce a single final good or service. Where once design and component production and assembly were co-located domestically, now component production may be assigned to a second, foreign, location, and assembly to a third.

Why might this occur? Papers in the literature typically build in a source of comparative advantage at the task level (due to technology, or factor supplies), but the realization of that comparative advantage depends on the interplay with trade and coordination costs. That is, China may have a comparative advantage in assembly of electronic components produced in Malaysia based on designs from US engineers, but to disaggregate these tasks profitably, to offshore them, requires effective coordination and inexpensive shipment. This suggests three basic channels as a spur to greater offshoring. One, firms may experience a reduction in trade and coordination costs (lower tariffs or improvements in shipping, information and communications technology) that lower the penalty associated with disaggregating a given set of tasks. Two, task requirements (or location comparative advantages for producing tasks) may

change. Three, there may be changes in the ability of the firm to coordinate production at a distance, or to transfer technological advantages from one location to another.

Offshoring is distinct from several related concepts including “outsourcing”, the activities of multinational firms, and import competition. Offshoring could involve outsourcing, by which we mean production of some tasks by arms-length parties (i.e. disaggregating tasks organizationally.) But outsourcing can occur domestically and offshoring can also be done by affiliated parties within the same, multinational, firm. In the jargon of the literature on multinational firms, vertical FDI is precisely an exercise in disaggregating tasks geographically, that is, offshoring. However, there are many motivations (horizontal and export-platform FDI) for multinational activities that do not fundamentally involve disaggregating the tasks associated with production. Finally, import competition can occur at the task level but also at the level of final goods. It can affect the profitability of firms and the returns to labor without altering the organization of production or location of operations for any firm.

With this intuition in hand, we can see a clear outline of the questions addressed by the offshoring literature. One, how important is offshoring as an economic as opposed to a media phenomenon, and how do we measure it distinctly from these related activities? Two, what are the policy or technological shocks that trigger a rise in offshoring, and how can these be used as a source of exogenous identification in empirical work? Three, what determines the mix of tasks that are produced offshore? Does this reflect differences in the factor intensity of these tasks, the costs associated with coordinating these tasks across far flung locations, or something else? Four, are the labor substituting effects of offshore production compensated

by changes in the scale and productivity of the firm? Five, how does offshoring affect wages and employment, unemployment rates and the earnings of displaced workers?

The paper proceeds as follows. In Section 2 we discuss work on measurement, including various approaches to understand the magnitude and patterns of offshoring. A recurring theme is the gap between conceptual ideas of offshoring and what is feasible to implement in the data. We highlight the three key elements of offshoring, and key stylized facts that have emerged from this literature.

In Section 3 we address theory and empirics on the effect of offshoring on relative labor demand and wages. We contrast older theories of trade and wages with new theories that highlight novel mechanisms through which offshoring affects labor markets. These include scope for intra-industry specialization along a continuum of tasks, sorting by firm type, productivity and scale gains, among others. We then address empirics, starting with an older literature using industry level data and proceeding through new work focused on firm level and matched worker-firm data. We organize our review around the type of data used and identification strategy employed, and draw out potential policy implications of the findings.

In Section 4 we address a fundamental question at the heart of public concern: are all tasks offshorable or are some jobs “safe”? Here we draw on a literature that examines the differential impact of offshoring across occupations, and that emphasizes the specific task content of those occupations in understanding the impact.

In Section 5 we discuss a collection of more novel insights about the effects of offshoring on the labor market. We contrast what we know about displacement due to offshoring with other causes of displacement, and discuss effects on long run unemployment

and transitions back to employment. We discuss how offshoring affects short run volatility and the elasticity of labor demand facing workers. We address empirical work on policy issues related to worker transitions and retraining.

In Section 6 we conclude with a brief discussion of lessons learned. We also highlight questions of interest that remain unanswered and could prove fruitful lines of inquiry for future research.

To be clear, the literature on offshoring has grown quickly, and when one digs deeper, connections to still larger literatures are apparent. Examples include trade research on multinational enterprises,³ firm heterogeneity with respect to exports, imports and quality,⁴ the literature on the organization of the firm,⁵ and so on. In order to keep the work (relatively) compact, we will touch on these as a point of reference for understanding the consequences of offshoring for labor markets, but not otherwise dig deeply into these literatures.

2. Measurement

In this section we describe various techniques used in the literature to measure offshoring, with a particular emphasis on methods that are employed in conjunction with empirical studies of the labor market effects of offshoring. We then discuss a set of stylized facts related to offshoring that will be useful in considering the theoretical and econometric literatures that follow.

³ See the recent survey Antras and Yeaple (2014).

⁴ E.g. Bernard and Jensen (1997, 1999), Verhoogen (2008). Examples of recent work include Antras, Fort and Tintelnot (2014) and Feiler, Eslava and Xu (2014).

⁵ See the surveys Antras and Rossi-Hansberg (2009) and Antras (2014).

Following our intuitive discussion of offshoring in the introduction we start by outlining the following three key elements of offshoring. First, offshoring is about intermediate inputs (or tasks) used for production, not final goods used for consumption. Second, offshoring is about imported inputs (or tasks), not domestically produced ones. Finally, offshoring is about an input (or task) that could have been produced internally within the same firm. We say “could have been”, not “used to be”, because for many new products offshoring takes place as soon as they are introduced into the market; e.g. the latest iPhone models are never assembled in the U.S. Puga and Trefler (2007) explore this issue in more depth, and Xiang (2014) reports evidence that produce cycles are getting shorter.

Among these three key elements we focus on the first and third ones below, since imports are easy to measure in the data.

2.1 Inputs vs. Final Goods

Offshoring is fundamentally related to input trade and so a natural place to begin is by disaggregating trade data into categories that are clearly examples of trade in inputs. A notable early example is Ng and Yeats (1999) who identify international trade in parts and components by, literally, searching for the words “part” or “component” in the descriptive labels within the Harmonized System nomenclature for traded goods.⁶ This approach is conceptually clear, and it allows for the maximum possible coverage since virtually all countries report bilateral trade data over long stretches of time. There are two weaknesses. First, many traded inputs are not listed as a “part” or a “component”. Second, if we want to estimate the

⁶ To be clear Ng and Yeats (1999) are not explicitly trying to measure offshoring in the way we have described it in the introduction. Instead they are focused on a closely related concept “production sharing”.

impact of input trade on labor market outcomes, it is necessary to identify who (which firm or which industry) is using the input. National trade statistics do not provide this information.

A second approach that addresses the input-user problem employs input-output tables combined with international trade data. Input-output tables reveal which inputs are used by which sectors, and in which proportion. A limited set of countries provide additional breakouts that permit a separation between a domestic IO table and a foreign IO table. That is, the distribution of input use may look different depending on the geography of the supply source. Even if countries do not separate suppliers by location, it is still possible to impute a foreign input-output relationship by using trade data along with a “proportionality assumption”.

To explain, we would like to measure the value of imports of input k by industry i at time t , OFF_{ikt} . From IO tables we know the total sales of k , S_{kt} and the use of input k by industry i both as a share of i 's output, a_{ik} , and in total, $A_{ikt} = a_{ik}Y_{it}$.⁷ However, we do not know the source country for those inputs. From trade data we know total imports of k , M_{kt} but not the industry i in which those inputs are used. Proportionality distributes imports across sectors by assuming that imports as a share of total sales for input k are the same in every using sector. That is, $OFF_{ikt} = A_{ikt} \frac{M_{kt}}{S_{kt}}$. Summing over all inputs k gives the total use of imported inputs by i , $OFF_{it} = \sum_k OFF_{ikt}$. It is straightforward to extend this to include indirect use of inputs, or to disaggregate imports into bilateral shares, or to employ services in addition to manufacturing sectors in the calculation.

⁷ Strictly speaking, input use coefficients can also vary across time as well but these appear to be relatively slow moving in the data. Whether this reflects slow updating of benchmark IO years or something more fundamental about technology is unclear.

Early examples of the proportionality assumption are found in Feenstra and Hanson (1999), but it also lies behind widely used “International” Input-Output tables constructed by the OECD and used by Hummels, Ishii and Wei (2001) in measuring the extent of vertical specialization. Recent efforts to document value added trade refine the proportionality assumption. Johnson and Noguera (2012a, b) further split imported inputs within an industrial aggregate using Broad Economic Classifications. This approach is reminiscent of Ng and Yeats (1999) use of “parts” and “components” to disaggregate trade flows. The BEC approach separates goods into capital machinery, intermediate inputs, and consumer goods, and then uses only intermediate inputs when distributing imports according to the proportionality assumption. Koopman, Wang and Wei (2014) provide further refinement and generalization of measures.⁸

One common element in these studies is that the measurement of offshoring is based on national trade statistics, which is publically available and can be implemented for a large number of countries. As a result, these studies reveal the following broad patterns of global trade in intermediate inputs, or production sharing.

1. Production sharing is rising rapidly, both absolutely and as a share of world trade. Most intermediate-goods trade is North-North, like final-goods trade.
2. The level of and growth in production sharing varies significantly across countries and industries. This makes it ideal for econometric work that would exploit these differences.

⁸ There is much discussion in this literature about the merits of various approaches to measuring production sharing. Rather than revisit this debate here, we direct the readers to these papers.

3. Production sharing is highly sensitive to trade costs, measured variously by geographic proximity, transportation costs, regional trade agreements, tariff rates, and export processing regimes.
4. Production sharing leads to profound changes in patterns of revealed comparative advantage (RCA). That is, when we properly account for which countries are adding value in different sectors, as opposed to simply focusing on gross exports, countries that appear to exhibit a comparative advantage for producing certain goods may not. Rather, their large volume of gross exports reflects specialization in only the last assembly stages, and large corresponding imports of products from earlier stages.

The main weakness of using national trade statistics is that ultimately, whether a product is an intermediate input or final good depends on who is using it. e.g. computers are final goods if they are purchased by consumers, but intermediate inputs if purchased by business instead. Recent research has made significant progress by bringing to bear firm-level data. Below we use Hummels, Jørgensen, Munch and Xiang (2014), or HJMX 2014, to illustrate the common approach used.⁹ Further discussion can be found in sub-section 3.4 through section 4.

HJMX (2014) measures offshoring as the total value of merchandise imports by manufacturing firms. The idea is to use the firms' industry classifications to distinguish between intermediate vs. final goods; i.e. the imports by a specific firm are primarily used as

⁹ See also the studies using data from Indonesia (e.g. Amiti and Konings 2007, Amiti and Davis 2011), Chile (e.g. Kasahara and Rodrigue 2008) and the U.S. (e.g. Bernard, Jensen, Redding, Schott 2007),

intermediate inputs in production, not final goods for consumption, if this firm is classified as *manufacturing*, not retail or whole sale.¹⁰

The use of firm-level data enables the researcher to specifically match the firms engaged in importing with changes in activities of those firms and to account for compositional differences within industries. When using national trade statistics and industry-level data, researchers maintain the proportionality assumption; i.e. technology, exposure to global shocks, and labor market consequences are identical across firms within that industry. Yet, firm level data reveal large differences in offshoring activity and its correlates across otherwise “similar” firms. To borrow an example from HJMX 2014, even a narrowly defined industry like medical devices includes firms producing artificial knees and hearing aids, and input purchases that include titanium hinges and electronic microphones.¹¹ In fact, the typical imported input is purchased by only a single importing firm.

In relation to measuring inputs vs. final goods, we regard firm level importing data as the “gold standard” for accuracy. However, it does have several limitations. One, it is available for a relatively small subset of countries. Two, the data is often times confidential and not accessible to all researchers. Three, by zooming in on individual firms within countries, firm-level datasets lose cross-country variation. Finally, while measures of merchandise imports are of high quality, services-imports coverage remains relatively weak.

¹⁰HJMX (2014) observe retail re-selling, with no value-added, by the firm. Retail re-selling is a small fraction of import purchases for manufacturing firms but a large or dominant share of purchases for service firms.

¹¹Jørgensen (2011) uses Danish to contrast production sharing measured at the firm versus industry level. He finds significant within-industry firm heterogeneity in input use, with larger, more capital and skill intensive firms embodying more foreign value added in the exports. This compositional difference causes industry level measures to understate the dispersion in foreign value added in exports across bilateral destinations.

2.2 How Do We Know That the Firm Could have Produced This Input (or Task) Itself?

We don't, in most cases, because this necessarily involves counterfactuals not present in the data. The standard approximation in the literature is pioneered by Feenstra and Hanson (1999). We discussed one of their offshoring measures previously in relation to proportionality assumptions, $OFF_{it} = \sum_k OFF_{ikt} = \sum_k A_{ikt} \frac{M_{kt}}{S_{kt}}$. They label this as *broad offshoring*, to indicate that it measures the most comprehensive set of inputs purchased by the firm. Under such a broad measure, many firms purchase inputs such as raw materials that they would not, and perhaps could not, have produced themselves. Therefore, while broad offshoring is useful for understanding patterns of input trade (after all, raw materials are inputs), it may not be helpful for understanding how changes in trade alter the mix of tasks that a firm performs. Accordingly, Feenstra and Hanson (1999)'s restrict the summation to include only the inputs in the same broad industry classification as industry i . This involves only the diagonals of the IO table, or $OFF_{iit} = A_{iit} \frac{M_{it}}{Y_{it}}$.

The idea for this second measure, dubbed *narrow offshoring*, is that we cannot observe the firm's ability to produce various inputs by itself. However, we can observe the similarity between the imported input and output of the using industry. More concretely, we are *relatively* confident that the auto industry is capable of producing auto parts itself but may choose to offshore production of auto parts. When we see the auto industry purchasing imported inputs from some other industry (textiles, glass, electronics) we are less confident that these represent inputs that could have been produced within the firm.¹²

¹² This same logic underscores the use of intra-industry trade indices by some authors to capture the extent of production sharing over longer time series. See Baldwin and Forslid (2014).

The studies using firm-level data have inherited, and then refined, broad and narrow offshoring. For example, HJMX (2014) distinguish between broad and narrow offshoring based on the output and input mix of an individual firm, rather than an industry. This refinement avoids the use of input-output tables or assigning imports based on the proportionality assumption. This approach is common among the studies using firm-level data, as we show later in this survey.

Our discussions so far highlight the challenge to find an ideal measure for offshoring, one that exactly matches all its three key elements. Fundamentally, we do not observe what firms are doing with sufficient detail to identify offshoring behavior comprehensively. Theoretical models of offshoring generally begin by assuming that firms engage in multiple activities or “tasks”. These may be linked to specific and identifiable inputs, as when a task corresponds to producing a particular material part or component. But tasks need not be linked in this way, as with services like design or marketing. Even with data that provide the most granular descriptions of firm activities and inputs, as we see in section 3.5, the link between activities and inputs remains necessarily inductive. Further, when we see a firm changing its activities – what it buys and sells, what primary factors it hires – it may be a challenge to separate changes due to offshoring from broader technological change or, more simply, firms deciding to switch the sets of goods they produce.

Recent attempts to capture an ideal measure for offshoring rely on firms formally acknowledging that they have engaged in offshoring. Park (2012) uses Trade Adjustment Assistance applications; firms in the US that have laid off workers due to an offshoring event will report this fact as part of workers’ TAA application. This is definitive acknowledgment that

offshoring has occurred, but it conditions on offshoring events that have particular labor market outcomes. Firms that offshore, become more productive and then expand their workforce do not generate displacement and TAA applications. Goos, Manning, and Salomons (2013), or GMS 2013, rely on public declarations of offshoring events reported via the European Restructuring Monitor. However, these declarations and acknowledgements are rare events when compared to the pervasiveness of input trade at the firm level. For example, GMS 2013 reports 17 Danish firms that experienced significant offshoring events during 2003-06. In the same period, Danish VAT register data report nearly 800 manufacturing firms who begin importing inputs and another 3000 who continuously imported foreign inputs throughout this period. These examples suggest that, while it is possible to identify specific reported events that correspond well to our conceptual understanding of offshoring, these events may not offer a representative look at the offshoring that actually occurs.

2.3 Other Approaches

Another approach to measuring offshoring focuses on the affiliate activities of multinational firms. Feenstra and Hanson (1997) use the number of foreign plants as a share of total plants within a sector i for Mexico as an indicator of the extent of offshoring to Mexico. Ebenstein, Harrison, McMillan and Phillips (2014) and Ottaviano, Peri and Wright (2013) measure offshoring using growth in employment for affiliates of US multinational firms. The advantage of relying on multinational firm data is two-fold. First, it gets closer to identifying particular firms that are changing the mix of activities due to foreign production. If we see a firm establish an affiliate abroad, or expand its employment, or engage in intrafirm trade, this

may provide evidence that activities that had previously been performed within the firm in the home market are now being done abroad. Second, multinational firms may capture a more general class of activities than can be identified using merchandise trade data alone. Even if no material inputs are exchanged between parent and affiliates there is, at a minimum, the exchange of headquarter services. The disadvantage of using multinational data to capture offshoring is that they entirely miss offshoring activities that occur in an arms-length way.

We conclude our survey for the measurement of offshoring by discussing two recent papers that have tried to improve on these weaknesses and to provide a set of additional insights about the nature of production sharing and offshoring. Fort (2015) examines the choice of US firms to purchase contract manufacturing services (i.e. specialized rather than commoditized inputs) from domestic and foreign partners. Fort (2015) finds that contract manufacturing is highly dependent on electronic codifiability (as measured by the use of CAD/CAM systems) and advanced communication technology (the use of electronic communication integrated with production process). These technologies are a stronger complement to domestic purchasing (outsourcing) than for foreign purchasing (offshoring). Offshoring of contract manufacturing services occurs relatively more with low income countries but the cost-lowering effect of technology is increasing in partner countries' human capital.

Bernard and Fort (2013) focus on "factoryless goods producers". These are plants and firms that are outside the manufacturing sector according to official government statistics but are nonetheless heavily involved in activities related to the production of manufactured goods. This entails primarily services tasks, including design, production coordination, and marketing and sales. This is a novel window into task specialization that has segmented goods production

activity entirely from service activities that are complementary to goods production. Put another way, in a world without task specialization, these activities would all occur within the same firm, which would likely be classified in government statistics as a manufacturer. Reclassifying factory-less goods producers to the manufacturing sector would increase the number of US manufacturing workers in 2007 by as much as two million.

3. Offshoring and wages

In this section we briefly review the literature on rising skill premium, which has motivated the development of the literature on offshoring and wages. We then review the theoretical work that examines how offshoring affects skill premium and wages. For the empirical work, we organize our review around the type of data used and identification strategy.

3.1 Background and Motivation

Historically, *the* primary theoretical tool for the study of how trade affects wages has been Stolper and Samuelson (1941), which can be illustrated using the following simple example. Suppose there are two closed economies, the North and the South. Both use two distinct inputs, skilled and unskilled labor, to produce two homogeneous goods that differ in skill intensity. The North is relatively abundant in skilled labor, so the skill premium (the wage of skilled labor relative to unskilled labor) is lower in autarky, as is the relative price for the skill-intensive good.

Now suppose free trade opens up between the North and the South. The relative price of the skilled-intensive good rises for the North, drawing resources away from the unskilled-intensive industry towards the skilled-intensive industry. As the latter expands, the relative demand for skilled labor rises in the North, driving up the skill premium. In response, both industries in the North reduce their skill intensities in production. These effects are reversed in the south, where the skill premium falls.

A large literature (e.g. Bound and Johnson 1992) shows that the skill premium rose substantially in the U.S. during the 1980s. Since the U.S. trade with developing countries also increased substantially during the 1980s the rising skill premium seems a promising testing ground for Stolper-Samuelson. However, it produces several puzzles that simple versions of Stolper-Samuelson cannot handle. One, the skill premia increased not just in the U.S. but in many developed and developing countries as well (Berman, Bound and Machin, 1998). Two, the rise in skill premium in the U.S. is mainly driven by within-industry increases in skill intensities, rather than the expansion of skilled-intensive industries relative to unskilled-intensive ones (Berman, Bound and Griliches, 1994). Three, using U.S. data Lawrence and Slaughter (1993) found no evidence that the import prices of skilled-intensive industries increased by more than their unskilled-intensive counterparts during the 1980s.

Based on these empirical failings, Davis and Mishra (2007) went so far as to declare that “Stolper-Samuelson is Dead”. The lack of empirical evidence for Stolper-Samuelson calls for additional theoretical mechanisms through which trade affects wages and the skill premium.

3.2 Theory for Offshoring and Wages

The theoretical literature on offshoring has grown rapidly in recent years. Examples include theories for the global supply chain (e.g. Antras and Chor 2013, Baldwin and Venables 2013, and Costinot, Vogel and Wang 2013), firm boundary and the choice between offshoring and FDI (e.g. Antras and Helpman 2004), and organizational hierarchies (e.g. Antras, Garicano and Rossi-Hansberg 2006). Many studies in these strands of literature have been the subjects of recent surveys, such as Antras and Rossi-Hansberg (2009), Antras (2014) and Antras and Yeaple (2014). To keep our survey (relatively) compact and to maintain our focus on empirics, in this sub-section we discuss the theoretical models that are closely related to the empirical studies we survey later in sections 3 and 4.

Feenstra and Hanson (1997) provide a model where increasing trade raises the skill premium in both the North and the South. Their key insight is to examine specialization along a continuum of intermediate inputs within a given industry. As in Stolper-Samuelson the North is relatively abundant in skill labor and has a higher skill premium in autarky. Here, however, there is a single final goods sector produced using a continuum of tradable inputs. These “inputs” can be physical parts and components, or service activities such as assembly, or research and development or marketing. The production of the inputs requires 3 inputs, capital, skilled and unskilled labor. While capital share in production cost is the same across inputs, skill intensity differs across inputs. If trade costs are zero for all inputs, and inputs are homogeneous, then in equilibrium the two countries divide the continuum, with the South specializing in a range of unskilled intensive inputs and the North produces the skilled intensive inputs.

To see the effect of a rise in offshoring on the skill premium, suppose the North exports capital in the form of FDI to the South. The cost of capital rises in the North and the North offshores more inputs to the South. This shifts the dividing point in the continuum in a particular way. The newly offshored inputs are more skilled intensive than those previously produced by the South, and less skill intensive than the inputs previously produced by the North. Therefore, both the North and the South experience a rise in average skill intensity, relative demand for skilled labor, and skill premium.¹³

The main intuition of Feenstra and Hanson (1997) -- changes in specialization along a continuum of inputs -- also goes through in an alternative setting. Suppose that inputs are produced using skilled and unskilled labor (no capital), and trade in inputs is costly. Similar to the classic continuum-goods model of Dornbusch, Fisher and Samuelson (1977), costly trade will mean that there is a range of non-traded inputs in which factor-based comparative advantage is not strong enough to overcome trade costs. Then, a reduction in trade costs will shift production of some inputs from North to South; these inputs are more skill intensive than those previously produced by the South and less skill intensive than those previously produced by the North.

Feenstra and Hanson (1997) explicitly model offshoring as trade in intermediate inputs, and provide an alternative theoretical framework for trade to affect wages. However, they employ two strong assumptions: there is only one sector, and the offshoring costs are the same for all inputs.

¹³ General equilibrium effects are in Feenstra and Hanson (1996). For more discussions see the surveys Harrison, McLaren and McMillan (2011) and Antras and Yeaple (2014).

Grossman and Rossi-Hansberg (2008)¹⁴ relax these assumptions and provide an alternative conceptual framework for offshoring by distinguishing between “goods” (e.g. cars and clothes) and “tasks” performed by individual workers (e.g. writing computer codes, doing paper work). There is a continuum of tasks performed by skilled workers and a second continuum of tasks performed by unskilled workers. There are two sectors, each producing one final good. Both sectors use skilled and unskilled tasks as inputs, but one relies more heavily on skilled tasks.

There are two countries, the North and the South. Assume initially that unskilled wages are higher in the North but skilled wages are the same in both countries. This creates an incentive for the North to offshore unskilled tasks to the South. Further assume that offshoring costs differ across unskilled tasks.¹⁵ This ensures that only the low cost tasks are offshored, while high cost tasks remain in the North. Note that both Northern sectors offshore, since they both use unskilled tasks, and that the offshored tasks have the same skilled intensity as the tasks that remain onshore. Here the onshore/offshore difference in specialization is driven by differences in the cost of offshoring, not by factor intensity.

Now suppose offshoring costs decrease by the same proportion for all unskilled tasks, and assume that the prices of both final goods remain unchanged. Profits rise in both Northern producers, but they rise more in the sector that intensively uses unskilled tasks. This leads to an expansion in that sector, and this between-industry movement increases demand for unskilled labor and decreases relative demand for skilled labor. Even though a set of unskilled

¹⁴ Recent theoretical extensions of Grossman and Rossi-Hansberg (2008) include Baldwin and Robert-Nicoud (2010) and Benz (2012).

¹⁵ Offshoring costs here could reflect costs of trade such as tariffs or shipping or it could represent the difficulty of managing and integrating particular activities from a distance.

tasks is being offshored, the overall expansion of that sector is sufficient to raise demand for the unskilled workers performing the onshore work. Summing up, as the North offshores more unskilled tasks to the South, the wage of unskilled labor increases, the wage of skilled labor remains unchanged so that the skill premium decreases. Grossman and Rossi-Hansberg (2008) call this “productivity effect” since it is similar to the effect of labor-augmenting technological progress.

Now what if skilled wages are also higher in the North, so that the North offshores both unskilled- and skilled- tasks to the South? To answer this question, assume that offshoring costs decrease by the same proportion for both skilled- and unskilled-tasks. Then the productivity effect applies to both skilled and unskilled labor, resulting in higher wages for all workers in the North. Whether the skill premium increases or not depends on other parameters of the model (e.g. how fast offshoring cost rises across skilled and unskilled tasks).

In addition to the productivity effect, Grossman and Rossi-Hansberg (2008) also discuss the relative price effect and the labor supply effect. The former is similar to the mechanism of Stolper and Samuelson (1941), which we discussed in sub-section 3.1. The latter operates as follows. As the North offshores more unskilled tasks, the unskilled labor in the North, who used to perform these tasks, is released and seeks employment elsewhere. This tends to decrease unskilled labor’s wage, like an increase in its supply. Alternatively, one can also think about this as a reduction in the demand for Northern unskilled labor’s services, and in this sense, the labor supply effect is similar to the mechanism in Feenstra and Hanson (1996, 1997), which we previously discussed. A theoretical contribution of Grossman and Rossi-Hansberg (2008) is that they examine all three effects in the same framework, and spell out the conditions for when

one of them dominates.¹⁶ In this survey we focus on the productivity effect, because it is unique to Grossman and Rossi-Hansberg (2008), and closely related to the empirical work we later discuss.

Despite very different assumptions and very different predictions, Feenstra and Hanson (1997) and Grossman and Rossi-Hansberg (2008) are complementary. Both model North-South, or one-way, offshoring, where the South has no incentive to offshore to the North. Feenstra and Hanson (1997) is a one-sector model (with one final good) and all the action is within-sector. Offshored and domestically produced inputs differ only in their skill intensities, so that offshoring is mainly about bundles of skilled and unskilled labor. Grossman and Rossi-Hansberg (2008) is a two-sector model (with two final goods) in which offshoring affects wages and the skill premium by shifting resources between sectors. *Within a given sector*, offshored and domestically produced inputs differ in offshoring costs, but have the same skill intensities.

Recent work has explored North-North, or two-way, offshoring, which we argue in Section 2 is an important and under-emphasized feature of the data. Burstein and Vogel (2010) assume two identical countries that have identical wages for skilled and unskilled labor. Following Feenstra and Hanson (1997), there is one sector producing a non-tradable final good, a continuum of tradable inputs, and identical trade costs across inputs.¹⁷ To provide an incentive for offshoring, Burstein and Vogel (2010) assume that input costs depend on input-specific productivities that are realizations of random draws from an underlying distribution in the manner of Eaton and Kortum (2002). The two countries are symmetric ex-ante because

¹⁶ For more details see the surveys Harrison, McLaren and McMillan (2011) and Antras and Yeaple (2014).

¹⁷ Burstein and Vogel (2010) also consider the more general case with two sectors and two countries that differ in relative skill endowments.

they draw from the same productivity distribution, but ex-post they specialize in those inputs that have high realized productivities.¹⁸ That is, both countries offshore production to the other, a feature that is absent from North-South offshoring models in which the South never offshores production to the North.

To get wage effects in this framework Burstein and Vogel (2010) assume that productivity is skilled-labor biased so that a high productivity draw increases skilled intensity. Now suppose trade cost falls. Each country expands the range of inputs that they offshore to their partner country, and tougher import competition leads non-exporting producers to contract in both places. Because exporters are more productive and (with the assumption of productivity-skill complementarity) more skill-intensive, this resource-reallocation increases relative demand for skilled labor and the skill premium in both countries. To summarize, Burstein and Vogel (2010) have provided a theoretical framework where offshoring takes place between identical countries, and a rise in offshoring raises skill premium in all countries by reallocating resources between exporting and non-exporting firms. These mechanisms are absent in North-South models of offshoring.

Grossman and Rossi-Hansberg (2012) explore North-North offshoring in the presence of an externality. Suppose there are two factors (skilled and unskilled labor) and two countries that have identical relative endowments for skilled labor but differ in size. There are many final goods, all freely traded, and each final good is produced by one distinct firm. Production requires both fixed and variable costs. Fixed costs take the form of headquarter services that use skilled labor and can be located in either country. Variable costs involve a continuum of

¹⁸ We can think about this simplified example for Burstein and Vogel (2010) as Feenstra and Hanson (1997) meets Eaton and Kortum (2002).

tasks produced using unskilled labor. Each task must be performed once per unit of final good, and across final goods, the set of tasks is the same.

The heart of the analysis is a country-level externality for task production: the productivity for a given task in country 1 (country 2) increases in the number of times this task is performed in country 1 (country 2). Grossman and Rossi-Hansberg (2012) allow firms to perform tasks on behalf of others. This creates an opportunity for firms to internalize some of the externalities and helps reduce the set of equilibria. If firm j performs a task for firm k , and j and k are headquartered in different countries, then j pays an offshoring cost. Offshoring cost differs across tasks, as in Grossman and Rossi-Hansberg (2008). Equilibrium involves firms choosing headquarters locations and prices for final goods and tasks, and then for each task choosing from three options: produce it in-house; outsource it to a domestic firm; or offshore it to a foreign firm. An important contribution here relative to the literature is to think about offshoring and domestic outsourcing as distinct but related outcomes.

Grossman and Rossi-Hansberg (2012) show that (i) the country with high aggregate output always has high unskilled wage,¹⁹ (ii) there is no trade for the tasks with highest offshoring costs, and (iii) for the tasks that are traded, the high-offshoring-cost (low-offshoring-cost) tasks are performed in the high-unskilled-wage (low-unskilled-wage) country. Beyond these, the other elements of the equilibrium depend on parameter values. For example, when offshoring costs are high for all tasks, there is no task trade unless countries differ enough in size; and when offshoring costs are modest there can be multiple equilibria. Using numerical exercises for specific parameter values, Grossman and Rossi-Hansberg (2012) show that a fall in

¹⁹ This result is reminiscent of Hanson and Xiang (2004), but the mechanism is different: here the result is driven by external scale economies, but the result in Hanson and Xiang (2004) is driven by internal scale economies.

offshoring cost may increase or decrease unskilled wage, but do not report how this affects skill premium.

We turn next to empirical work, organized into three roughly chronological waves. As a quick reference for the readers, Table 1 summarizes the data, measurement for offshoring, and identification strategy of the empirical papers we survey in sub-section 3.3 through section 4. Table 2 summarizes the numerical results of these papers. To facilitate comparison across studies we have used the reported coefficient estimates to calculate the effects of a 10% increase in offshoring. Since the measurement and specification of offshoring vary across studies, so does the precise meaning of “10% increase in offshoring”. To be specific, it is: (1) 0.1 log point, for the studies that specify offshoring in logs; (2) 10% of sample mean or median, whichever is reported, if offshoring is not in logs; or (3) 10% of the mid-point of the range of values, if neither mean nor median is reported and offshoring is not in logs.

3.3 Empirical Results for Offshoring, Wages and Productivity: Wave 1

The initial wave of research exploits industry-level data in a panel structure with relatively few time periods to study how a change in offshoring affects relative demand for skilled workers within that industry. We highlight key differences and findings next, and discuss a set of challenges related to measurement and identification.

A common starting point for these papers is the specification of Berman, Bound and Griliches (1994). They use a translog cost function and derive relative skill demand, measured by the skill labor share of the wage bill, as a function of the capital-output ratio and other controls. The papers we discuss extend that specification by incorporating offshoring as a

factor that shifts the relative cost shares for skilled labor. This is theoretically motivated by the model of offshoring in Feenstra and Hanson (1997), and is conceptually equivalent to examining how a change in offshoring alters the set of tasks that are accomplished within an industry.

A rough summary of the common estimation framework for the papers in Wave 1 is,

$$(1) \quad \Delta S_{it} = \alpha + \beta \Delta \text{OFF}_{it} + \gamma \Delta \text{CONTROL}_{it} + \varepsilon_{it}.$$

In Equation (1) “*i*” indexes one cross-section observation in the data, such as one industry or one industry x region, “*t*” indexes time intervals, and “ Δ ” represents the change within the interval. The dependent variable, S_{it} , is the skilled labor (or nonproduction labor) share of the wage bill, OFF_{it} is the main offshoring variable and CONTROL_{it} a vector of control variables. Fixed effects that are *i*-specific are absorbed by estimating in differences.

Feenstra and Hanson (1997) use data from the Mexican Industrial Census and examine changes in the relative demand for skilled labor in Mexico during 1975-1988. Motivated by their model in which offshoring is triggered by foreign direct investment from the US, the key offshoring measure is the number of foreign plants relative to the number of domestic plants in an industry. “*t*” corresponds to the three intervals of 75-80, 80-85 and 85-88, “*i*” is one industry x state, and S_{it} is measured using non-production workers’ share in total wage bill. CONTROL_{it} includes domestic capital stock and average wages for professional and food services, which proxy for average wages for skilled and unskilled labor.

Regressions of this sort must deal with a fundamental endogeneity problem. Over time, changes in technology or in the mix of firms or products within the industry might lead to both a change in skilled labor demand and a change in the returns to offshoring production. Ideally,

the regression structure should exploit some exogenous variation in the cost of engaging in offshoring.

Feenstra and Hanson (1997) rely on two arguments. First, they document the major revisions of trade and investment policies by Mexico during the 1980s, arguing that much of the variation in ΔOFF_{jt} is driven by these exogenous policy changes. In addition, Feenstra and Hanson (1997) experiment with instrumenting ΔOFF_{jt} by distance to the nearest US border crossing (plus other variables). The idea is that most foreign investment in Mexico comes from the U.S., and U.S. producers prefer setting up plants in the states close to the U.S.-Mexico border in order to save on shipping and coordination costs. Between these two approaches Feenstra and Hanson (1997) emphasize policy changes rather than the IV approach.

Feenstra and Hanson (1999) turn their attention north of the border and show that offshoring increases the relative demand for skilled labor in the U.S. during 1979-1990. “i” indexes four-digit manufacturing industries, “t” is a single long difference over the whole period 1979-1990, so that the regressions exploit only cross-sectional differences in growth with no industry fixed effect. The paper offers several improvements on Feenstra and Hanson (1997). First, $CONTROL_{it}$ includes capital-labor ratio, real output, and the following two measures for technological change: share of office and computer equipments in capital, and share of high-tech equipments in capital. This captures the possibility that particular kinds of capital investment and technological change might be skill biased in its productivity impact. Second, and as we describe in detail in Section 2, they develop broad and narrow offshoring. Critically, they assume that changes in these measures – which industries increase imported input use at a more rapid rate – are exogenous with respect to changing skill use within the industry.

Feenstra and Hanson (1997) find that the increase in US foreign investment in Mexico during the 1975-1988 period could account for over half of the rise in skilled labor's share of the wage bill in those Mexican regions where foreign plants are concentrated. Feenstra and Hanson (1999) find that the increase in offshoring could explain 15%-40% of the increase in US skilled workers' share in wage bill during 1979-1990. Consistent with their model, offshoring contributes to the rising demand for skilled labor in both Mexico and the US.

Hsieh and Woo (2005) apply the approach in Feenstra and Hanson (1999), including their measure of broad offshoring²⁰, to study how offshoring to China affected industry relative demand for skilled labor in Hong Kong from 1976-1996.²¹ There are a few important differences relative to the earlier work that improve the identification of the offshoring effect. First, while they do not have measures of within industry technological change, they exploit changes over multiple five year periods so that they can incorporate both time and industry fixed effects.²² Differencing over a five year period eliminates cross-industry variation in levels. Combining this with industry effects allows the authors to exploit different rates of change over the five year windows. This is helpful for eliminating spurious industry-specific trends in skill use that might be correlated but not caused by offshoring.

Second, they exploit China's decision to open its market to foreign investors in 1980. This had a very large impact on Hong Kong, given its small size and close proximity to China. To show this point, Hsieh and Woo (2005) document that the employment share of offshoring-related service industries rose from 33% in 1981 to 50% in 1996. In addition, given China's

²⁰ Another measure for offshoring is imports from China relative to the sum of these imports and domestic output

²¹ A number of other papers have used the methodology in Feenstra and Hanson (1999) to study how offshoring affects the demand for skilled and unskilled labor in other countries (e.g. Hijzen, Görg and Hine 2005 for the U.K.).

²² "t" represents four intervals: 1976-81, 1981-86, 1986-91, and 1991-96. Earlier data from the 1971-76 interval is used as a control.

comparative advantage, China's policy change in 1980 has larger impacts on labor intensive industries and smaller impacts on skilled-intensive industries, *ceteris paribus*. Hsieh and Woo (2005) use two instruments for changes in offshoring: the labor share in value-added, and the skilled labor's share of the wage bill share for each industry in 1976.²³

Hsieh and Woo (2005) find that the increase in offshoring from China during 1981-1996 could account for 40%-50% of the increase in the relative demand for skilled labor in Hong Kong's manufacturing sector. They also note that a reallocation of output from manufacturing to services accounts for 10%-20% of the increase in relative demand for skilled labor in Hong Kong between 1981-1996, while movements within manufacturing accounts for 25-35%.

Amiti and Wei (2006) examine how offshoring both services and material inputs affects labor productivity by U.S. manufacturing industries from 1992-2000. They use a specification similar to (1) except that the dependent variable is output or value-added per worker rather than a measure of relative skill demand, and they include year and industry fixed effects. The offshoring measure is similar to Feenstra and Hanson (1999)'s broad offshoring, but they include separate measures of service offshoring and material offshoring. To address the endogeneity of changes in offshoring they use lagged values as instruments. Amiti and Wei (2006) find that service offshoring accounts for 10% of the growth in labor productivity of the U.S. manufacturing industries during 1992-2000, while the results for material offshoring are statistically insignificant. In related work Amiti and Wei (2009) find that service and material

²³ Hsieh and Woo (2005) enter the two instruments separately in the first-stage regressions. Both instruments have the right signs, but the labor-share instrument captures more variation in offshoring. Note that the second instrument is a lagged (level) version of the same variable used to construct the dependent variable (in differences).

offshoring has little effect on employment changes of the U.S. manufacturing industries during 1992-2000.²⁴

In summary, the empirical studies in wave 1 have told us that increases in offshoring raise relative demand for skilled labor and contribute to rising skill premium in both the North and the South. They also suggest that offshoring might affect employment, a point we re-visit in section 5 below. These results clearly shed light on the effects of globalization on income inequality and returns to college education. One caveat, though, is that changes in *skill premium* have ambiguous implications for changes in *wage levels*. A rise in skill premium in the U.S., for example, could be consistent with falling wage levels for both skilled and unskilled workers, the former at a slower rate. This scenario would be of little comfort for policy makers and public audience, who may be especially concerned about rapidly rising college tuition. We will come back to this point when we survey wave-3 studies below.

In addition, the wave-1 studies have examined both North-South and North-North offshoring. Feenstra and Hanson (1997) use U.S.-Mexico, Hsieh and Woo (2005) Hong Kong-mainland China, and Feenstra and Hanson (1999) include U.S. imports from every trading partner, both Northern and Southern countries. This suggests to offshoring theory that both North-South and North-North offshoring matters for wages and skill premium. Beyond this, however, the wave-1 studies have not told us which theoretical mechanism is at work. For example, Feenstra and Hanson (1997,1999) and Hsieh and Woo (2005) are consistent with the view that offshoring allows countries to specialize, within industries, along lines of factor abundance. However, they cannot be used to rule out other explanations. For example,

²⁴ The specification in Amiti and Wei (2009) is similar to Amiti and Wei (2006), except that the dependent variable is employment, and controls include average wage and average output price.

offshoring may affect productivity within the firm, and if productivity is factor biased, as in Burstein and Vogel (2010), offshoring can drive changes in skill demand even if task specialization were not based on factor abundance.

3.4 Empirical Results for Offshoring, Wages and Productivity: Wave 2

Evaluating the effect of offshoring on wages at the industry level, as in Wave 1 studies, faces several identification challenges. First, a large new literature using firm level data has clearly established that there exists substantial within-industry heterogeneity in firm size, productivity, factor use and participation in global markets (both exporting and importing). This makes it difficult to discern whether industry-level variables reflect changes occurring for each firm within an industry or instead reflect compositional change within the industry.²⁵

Second, the validity of instrumental variables designed to identify exogenous changes in offshoring may be in question when an industry is facing changes in demand or technology that are correlated with input choices of the firm. Use of firm level data can be useful in this respect because it provides within industry variation that allows researchers to control for industry level shocks to demand or technology. Similarly, changes in policy or other shocks to the trade environment that differentially affect sets of firms within the industry can provide better instruments for identifying shocks.

Biscourp and Kramarz (2007) use French firm level data to measure the impact of offshoring on employment of production and nonproduction workers between 1986/87 and

²⁵ For example, faster growth by firms that both use more imported inputs and devote a larger share of their wage bill to skilled workers could generate all the facts uncovered in the papers cited in 3.3.

1991/92.²⁶ The structure of the regressions is similar to equation (1), but where “i” indexes manufacturing firms, the dependent variable is firm employment, and the control variables include sales, measures of technology change such as production of new products and R&D, and firm-level exports.

Biscourp and Kramarz (2007) do not explicitly use the word “offshoring” but instead refer to imports or trade. For a given manufacturing firm *i*, they distinguish “final-goods”, or “FG”, imports, versus “intermediate inputs”, or “II”, imports, where “FG” is the imported products in the same industry as *i*’s output, and “II” is all the other imports. In comparison to Feenstra and Hanson (1999) “FG” is narrow offshoring and “II” the difference between broad and narrow offshoring. In addition, they distinguish between three regions of import source country: within the EC, OECD countries outside of the EC, and non-OECD countries.

The main finding of Biscourp and Kramarz (2007) is that a rise in narrow offshoring is strongly correlated with fall in firm employment, especially for the employment of nonproduction (unskilled) workers. This is consistent with many Wave-1 studies, but the firm level data adds an important dimension to the earlier results because it makes clear that changes are occurring within firms rather than occurring only across firms. In addition, the negative effects of offshoring on employment growth rates are similar in magnitudes for all three source country groups.²⁷

One caveat with Biscourp and Kramarz (2007) is that they treat offshoring as exogenous with respect to employment. This is especially concerning since at the firm level, as unobserved

²⁶ During this period the French labor market featured both wage rigidity and high separation costs, which makes it unsuitable for analyzing wage change.

²⁷ Biscourp and Kramarz (2007) also tabulate the contributions to total employment change by firms of different types. Firms are classified by size, import/export status, rise/fall in import-to-sales ratio, and continuing/dying firms. These descriptive exercises show that the largest contributor to total employment change is dying firms.

firm characteristics (e.g. productivity) likely drive both offshoring and employment decisions.²⁸

To progress beyond correlations it is important to identify variation in offshoring that is exogenous to individual firms. To gain identification, several papers exploit the insights of theoretical models in which costs of offshoring differ across firms.

One important approach uses exogenous policy changes as natural experiments. Amiti and Davis (2011) consider Indonesia's trade liberalization during 1991-2000. The liberalization led to substantial tariff cuts that were plausibly exogenous with respect to individual firms but whose impact varied across firms depending on their product mix.²⁹

To motivate their analysis, Amiti and Davis (2011) write down a theoretical model with firm heterogeneity to clarify the mechanisms through which tariff cuts affect average wages of Indonesian manufacturing firms. Firms can choose to export, offshore (i.e. import inputs), or both, as a function of productivity and the fixed and variable costs of both exporting and offshoring. Firms hire homogeneous workers but set "fair wages" in which wages are an increasing function of variable profit. In this framework the effects of tariff cuts vary across firms, depending on the firms' trade status. As the output or input tariff falls for industry i , increased competition drives down wages in the firms of industry i that only participate in the domestic market. However, these falling tariffs lower production costs and increase profits for the offshoring firms of industry i , while boosting sales and profits for the exporting firms of

²⁸ See the discussion in Section 3.2. For empirical papers linking imports to firm productivity see Amiti and Konings (2007), Kasahara and Rodrigue (2008), Goldberg et al (2010), Bustos (2011), and Halpern, Koren and Szeidl (2015).

²⁹ Since the magnitudes of the tariff cuts might be influenced by industry lobbying, Amiti and Davis (2011) use a differencing specification, where every variable is in 5-year differences. In addition, they use the following instruments for input and output tariffs: (a) unskilled labor's share in wage bill of an industry in 1991 (this is a similar idea to Hsieh and Woo 2005); (b) whether an industry has a product with non-tariff barriers; and (c) whether an industry contains 10 or more products for which Indonesia is not obliged to cut tariffs.

industry i . Thus the firms that export or offshore production increase wages relative to the domestic firms of the same industry.

Amiti and Davis (2011) exploit panel data with firm-by-year variation to examine changes in firm average wage (they do not have data for individual workers' wages). The main explanatory variables are industry-level output and input tariffs (constructed as averages of product line tariffs) and their interactions with firms' export and import status.³⁰ The effect of tariffs changes on average wages closely matches the theoretical predictions. An implicit, and important, assumption here is that an output-tariff cut by Indonesia is accompanied by similar cuts in the tariffs of Indonesia's trade partners for their imports from Indonesia. Note that the estimation strategy does not exploit changes in the value of offshoring for each firm but instead focuses on changes in the cost of offshoring arising from changes to tariffs.

Mion and Zhu (2013) use Belgian firm level data from 1996-2007 to estimate how offshoring and import competition affect firm outcomes such as employment growth, survival probability, and the fraction of non-production/skilled workers. Two elements of this paper are particularly noteworthy. The first is separately incorporating two related variables that may have very different effects on firms and workers: firm-level measures of offshoring in the manner of Biscourp and Kramarz (2007)³¹ and industry level import penetration as a measure of import competition. Mion and Zhu (2013) further distinguish import penetration and

³⁰ The output tariff for industry i is the simple average across the products of i . The input tariff of i is a weighted average of the output tariffs of the industries from which i purchases inputs, where the weights are input shares. Both the input shares and input-output relationship are based on 1998 industry-level input-output table. The authors also consider alternative measures for output and input tariffs, such as those based on the 1995 input-output table.

³¹ Mion and Zhu (2013) employ categories of offshoring as in Biscourp and Kramarz (2007), and separate import competition and offshoring by the four regions of China, other low-wage countries, OECD and rest of the world.

offshoring by source countries into four groups: OECD, China, other low-wage countries, and rest of the world.

Second, in a regression of various firm outcomes on import competition and offshoring measures, Mion and Zhu (2013) instrument for offshoring using trade weighted exchange rates and tariffs, where the trade weights are constructed using 1-year lagged import values.³² However, the IV and OLS estimates are qualitatively similar. They point out that, while pre-sample import shares will make better instruments, they settle for 1-year lagged values instead because firm import behavior changes substantially over time. In other words, the variations in tariff and exchange rates are too small to be compatible with pre-sample import shares. We revisit this point in sub-section 3.5.2 below.

Mion and Zhu (2013) report many coefficient estimates, for import penetration and offshoring, both distinguished by source country group. There are two broad patterns. First, statistical significance shows up for all country groups. E.g. narrow offshoring to China and to the rest of the world both increase firms' survival probability. Second, the effects for China are more pronounced than for other source country groups. E.g. both import competition from China and offshoring to China increase the fraction of non-production workers.

To summarize, the Wave-2 studies have shown: (1) that offshoring has significant effects on wages and employment within individual firms; and (2) how to identify the causal effects of offshoring by using exogenous policy changes as natural experiments.³³ Unfortunately, this approach is not helpful for studying causal effects of offshoring in countries that have not

³² The instrument for import competition is similar, but trade weights are based on pre-sample import values.

³³ Many studies using firm-level data and natural experiments are outside the scope of our survey. Examples include Verhoogen (2008), using Mexican data and the Peso crisis, and Bøler, Moxnes and Ulltveit-Moe (2015), using Norwegian data and a change in R&D tax credit.

experienced major policy change in the relevant period. We address alternative approaches next.

3.5 Empirical Results for Offshoring and Wages: Wave 3

The most recent wave of research has focused on worker-level data, in many cases using matched worker-firm datasets. Relative to work that uses firm- or industry-level aggregates this work has several advantages. Many adjustments to offshoring shocks may occur through changes in the composition of the workforce. At the broadest level this takes the form of changing the mix of skilled and unskilled workers, a central focus of the Wave 1 studies. But within these broad aggregates there is considerable heterogeneity in worker ability. Firms may adjust to offshoring shocks by changing the distribution of ability within broader aggregates in ways that raise (or lower) average wages and labor productivity. Investigating the impact of offshoring on specific workers is a way to address unobserved forms of worker heterogeneity and the extent to which compositional change can mask the measured impact of offshoring on industry aggregates.

In addition, a growing literature focuses on labor market returns that are match-specific (e.g. Abowd, Kramarz and Woodcock 2008). That is, a particular worker may be more productive when matched to a firm that requires the specific (unobservable to the econometrician) attributes of that worker. Examining offshoring induced changes in wages and productivity specific to a worker-firm match combines the benefits of Wave 2 studies (tighter identification of which firms are affected by offshoring shocks) with the benefits of studying heterogeneous workers.

The papers in Wave 3 use wages and worker characteristics that correlate with wages in an augmented Mincer regression. The following is a rough summary of their common specification

$$(2) \quad \ln W_{ijt} = \alpha + \beta_1 \text{OFF}_{jt} + \beta_2 \text{EXP}_{jt} + \gamma \text{CONTROL}_{ijt} + \varepsilon_{ijt}.$$

“i” indexes workers, “j” indexes the workers’ affiliation, such as industry, occupation, or firm, “t” indexes time, and ε_{ijt} is the error term. The dependent variable, W_{ijt} , is worker wages (or, alternatively, annual earnings). Controls may include worker or affiliation j characteristics, and the variables of interest may include exporting, EXP_{jt} , as well as offshoring activity, OFF_{jt} .

Unlike the industry level Wave 1 studies captured in equation (1), (2) is not typically expressed in first differences. Instead it uses annual variation while controlling for time trends and using fixed effects. In addition, wage variables are typically measured at the worker level but the offshoring measure only varies across j. This has the interpretation that an offshoring shock hits a larger group (firm, industry, occupation), and the econometrician is comparing wage changes for workers belonging to that group relative to other groups.³⁴

Below we organize the papers in Wave 3 by the types of data they use. We will focus on the results for offshoring. The results for exports are in footnotes.

3.5.1 Publicly Available Worker-Level Data

The US Current Population Survey (CPS) is annual and includes labor market variables for individual workers such as earning, education attainment, number of weeks in

³⁴ As in the Wave 2 studies, this assumes that there is some friction in the labor market which prevents wages for ostensibly similar workers from being equalized across those groups. In contrast, the Wave 1 studies are focused on skilled labor’s share of the wage bill under the assumption that wages for similar workers are equalized across industries so that only relative quantities of labor vary.

unemployment, and industry and occupation affiliation, in addition to a host of variables describing worker characteristics (age, gender, experience, etc). While the CPS does not consistently track workers over long time periods, it does survey a given worker in two consecutive years.³⁵ The CPS worker data can be matched to trade data either by industry or by occupation, allowing researchers to study the labor market impact on that worker of trade shocks hitting the worker's industry or occupation during a year in which the worker is sampled.

Liu and Trefler (2008) use the CPS data to study how U.S. offshoring to China and India affects U.S. labor market outcome during 1995-2006. They use trade data collected by the US Bureau of Economic Analysis (BEA) and measure offshoring as the value of U.S. imports of other private services from China and India whose transactions took place between unaffiliated parties. In comparison, the offshoring data used in most other studies is the sum of affiliated-party and unaffiliated-party trade.

To estimate the effects on industry and occupation switching, Liu and Trefler (2008) use a specification similar to (2). The dependent variable is a dummy that equals 1 if worker i switches industry or occupation between years $t - 1$ and t . To estimate the effects on time spent in unemployment and earnings, the specification is similar to (1). Liu and Trefler (2008) deal with the endogeneity of offshoring in two ways. First they argue that much variation in offshoring is driven by unilateral trade liberalizations by China and India that are exogenous to the U.S. In addition, they instrument for offshoring to source country j using its ratio to U.S. imports of similar services from the G8 countries. The idea is that this ratio controls for the

³⁵ At least in principle they are surveyed twice then dropped. In practice, researchers have to match the workers in consecutive years using an algorithm such as Madrian and Lefgren (2000) that finds common characteristics for households at both points in time. The rate of successful matches varies but typically lies between 60% and 70%.

effect of global technological change (e.g. information technology), which may simultaneously drive offshoring and the earnings of U.S. workers, and captures variation that is primarily driven by China and India's policy changes. Liu and Trefler (2008) find that under both OLS and IV, U.S. offshoring to China and India has small effects on occupation and industry switching, share of time in unemployment, and earnings.³⁶

Ebenstein, Harrison, McMillan and Phillips (2014), or EHMP 2014, use similar data to Liu and Trefler (2008), but ask a more subtle question: does offshoring affect wages through industry or occupation switching? EHMP 2014 use the variation in the CPS data in two ways: cross-industry and cross-occupation. The former (latter) captures the effect of offshoring by examining how wages change for a worker following occupation (industry) switching. EHMP (2014) use a specification similar to (2). W_{ijt} is wage. OFF_{jt} is the *employment* by foreign affiliates of U.S. multi-nationals and EHMP 2014 distinguish offshoring to low-income versus high-income countries. This measure of offshoring is different from Liu and Trefler (2008) and also different from most other studies. EXP_{jt} is the ratio of exports to output. Finally, since the specification is in levels and not in differences, there is no need to match workers in consecutive CPS years, and so all workers in the CPS data can be included when cross-occupation variation is used. For cross-industry variation, however, only manufacturing workers can be included, because data for the control variables (e.g. capital-labor ratio, computer use) is not available for service industries.

EHMP 2014 find that offshoring has insignificant effect on wages using cross-industry variation. Using cross-occupation variation, however, they find that low-income-country

³⁶ Liu and Trefler (2008) also study the effects of U.S. exports to China and India, and find them small. Their instruments for exports are similar to those for offshoring.

offshoring is associated with wage declines.³⁷ This negative wage effect is more pronounced for the later years of the sample, 1997-2002. This suggests that offshoring may lower wages through occupation switching.

EHMP 2014 do not address the endogeneity of offshoring,³⁸ and Liu and Trefler (2011) have followed up on this issue. Using an offshoring model based on Grossman and Rossi-Hansberg (2008) they point out that: (1) a positive shock to an industry's domestic demand or TFP increases both offshoring and labor demand, implying an upward bias of the OLS estimate of the wage effect of offshoring; and (2) a wage shock originating in the source country of offshoring has no direct impact on the industry's labor demand except through changes in offshoring, implying that such foreign supply shocks are good instruments for offshoring. Liu and Trefler (2011) show that in the presence of worker sorting, outside shocks, such as offshoring, may have different effects on the probability of switching up (i.e. a worker switching to an occupation with higher inter-occupational wage differential, or IOWD) than on the probability of switching down.

Liu and Trefler (2011) estimate the effects of U.S. offshoring to China and India on the probability of switching up and switching down.³⁹ The data, other aspects of the specification,

³⁷ They also report that high-income-country offshoring and exports are both associated with wage increases while import competition is associated with wage decreases.

³⁸ EHMP 2014 address the concern that their finding is driven by the common time trend in offshoring, wage and technological change by doing the following falsification exercise. They replace the lagged values of the offshoring variables with their future values in 2002, and find that future offshoring does not have significant wage effects for the early years of the sample, 84-89.

³⁹ IOWD is estimated as the occupation fixed effects in a Mincer wage regression using the CPS data.

and the variables used are all similar to Liu and Trefler (2008).⁴⁰ Liu and Trefler (2011) use cross-occupation variation but not cross- industry variation.

Liu and Trefler (2011) construct the following instrument for offshoring. They estimate a gravity equation for offshoring, and then take the coefficient estimate of GDP-per-capita and multiply it with the GDP per capita of China and India. The idea is that GDP per capita in China and India proxy for wages there, and the gravity-equation coefficient estimate captures how these wage changes affect offshoring.⁴¹

Liu and Trefler (2011) find that U.S. offshoring to China and India has larger effects on switching down than on switching up,⁴² and that the IV estimates are qualitatively similar to the OLS estimates.

3.5.2 Matched Employee-Employer Data

Another source for individual workers' data is matched employee-employer data sets. While they have been used in the labor literature since the 1990s (e.g. Abowd and Kramarz 1999), they have only recently been used to study how offshoring affects labor market outcome. Matched employee-employer data provide both firm characteristics, like the data discussed in sub-section 3.4, and worker characteristics, like those discussed in 3.5.1. In addition, matched employee-employer data identify which worker is working with which firm, and typically allow researchers to consistently track workers and firms over time.

⁴⁰ Liu and Trefler (2011) add two control variables: domestic demand, measured as total sale minus exports, and IC technology, measured as the share of IC equipments in total investment (similar to Feenstra and Hanson 1999).

⁴¹ Liu and Trefler (2011) construct a second instrument for offshoring using the GDP per capita of the G8 countries, plus two similar instruments for exports. Liu and Trefler (2011) include all four instruments in the first stage regressions of both offshoring and export.

⁴² Liu and Trefler (2011) also estimate the effects of offshoring on the probability of workers switching to unemployment status, the wages of the workers who do not switch occupations, and the wages of those who do.

Unfortunately, all the matched employee-employer data sets that have been used are confidential, and access to them has to be arranged with statistical agencies.

Matched employer-employee data allow researchers to accurately measure offshoring, and cleanly identify the causal effects of offshoring on wages. Hummels, Jørgensen, Munch and Xiang (2014), or HJMX 2014, use Danish data for 1995-2006, and their main specification is in the framework of (2). W_{ijt} is hourly wage (earnings are also used), and the specification includes region, industry-by-year, and job-spell fixed effects. The use of job-spell fixed effects implies that the identification is based on changes within a given worker-firm match; i.e. while worker i is employed by firm j , what happens to i 's wages if j increases offshoring for exogenous reasons? In addition, job-spell fixed effects sweep out time-invariant worker and firm characteristics, $CONTROL_{ijt}$ contains additional time varying characteristics for workers and firms. They also interact offshoring and exporting measures with a skill dummy (equals 1 for college-educated workers) to capture differential impacts by worker type.

HJMX 2014 construct two firm-time varying instruments for offshoring and exports that focus on changes in supply (or demand) conditions outside Denmark and the cost of providing inputs into Denmark. The first instrument is world-export supply, or WES. Suppose Danish firm j imports product k from country c in year t . The instrument for this import flow is then country c 's export of product k to the rest of the world, minus Denmark, in year t . If there is a shock to the supply of k from c (e.g. a drop in wages, an increase in productivity, a rise in quality, an expansion of variety, or all of the above) that will lead to an expansion of sales worldwide and be captured in WES. These foreign supply changes affect the wages of Danish firm j only

through WES.⁴³ Further, because Danish firms purchase a different mix of inputs, even within the same industry, the impact of the various c-k specific shocks will have differential impact across firms.⁴⁴

In this period Denmark experienced only minor changes in trade policy, but did experience significant changes in shipping costs induced by large shocks to world oil prices. While oil shocks are common, their impact on delivered prices varies considerably across firms based on distance to market, product weight/value, and modal choice. Since the WES instrument (and its counterpart for exports) and fitted measures of shipping costs are straightforward to construct, they provide one solution to the identification challenge discussed at the end of sub-section 3.4; namely, how to deal with the endogeneity of offshoring in the absence of a major policy change? This solution may be especially useful for the studies that use matched employer-employee data, because: (a) many of these data sets come from countries with a stable external trade environment, like Denmark, for which changes in tariffs and exchange rates do not provide sufficient variation (see our discussion for Mion and Zhu 2013 in sub-section 3.4); and (b) at the firm level endogeneity is likely to be a serious concern. In addition, in sub-section 4.2 we show that these instruments can also be constructed for industry- and occupation-level data.

HJMX 2014 show that offshoring lowers the wages of low skilled workers and raises the wages of skilled workers within job spells, while exporting increases the wages of both skilled and unskilled workers within job spells. The estimated negative effects for low skilled workers

⁴³ Autor, Dorn and Hanson (2013) use a similar IV strategy to estimate the effects of Chinese import competition on U.S. manufacturing employment (see also our earlier discussions for Liu and Trefler 2011).

⁴⁴ To capture this differential impact, HJMX 2014 weight individual c-k specific flows by pre-sample shares in firm j 's imports.

are nearly 10 times as large using IV relative to OLS. The difference in estimates is consistent with the typical prediction of firm-heterogeneity models that more productive firms do more offshoring and pay higher wages. Focusing on exogenous changes in offshoring clearly isolates the negative causal impact.⁴⁵ When HJMX 2014 restrict to their data to Danish offshoring to high-income countries, they obtain similar results.

In related work, Martins and Opromolla (2009) use Portuguese data for 1995-2005 and a specification similar to equation (2), where W_{ijt} is hourly wage of individual workers. $CONTROL_{ijt}$ includes the usual set of worker and firm characteristics, as well as work hours of individual workers. Martins and Opromolla (2009) experiment with job-spell (i.e. worker-firm) and separate worker and firm fixed effects.⁴⁶ Offshoring is measured as aggregate imports by manufacturing firm j in year t (either a dummy for positive import value, or the ratio of import value to total sales) with similar measures for exports. Products are also separated into high- and low-tech categories based on an OECD classification. They find broadly similar results across different specifications; in particular, high exports of high-tech products are associated with high wages, but the effects of offshoring are typically not statistically significant. Following our discussion of HJMX 2014, this may be because Martins and Opromolla (2009) do not address the endogeneity of offshoring or exports.

The studies in waves 2 and 3 have made progress in informing economic theory about offshoring, relative to those in wave 1. First, most papers in waves 2 and 3 find similar effects

⁴⁵ HJMX 2014 also show that under the IV estimation, offshoring increases the wages of skilled workers within job spells, and that export increases the wages of both skilled and unskilled workers within job spells.

⁴⁶ Krishna, Poole and Senses (2014) highlight the importance of controlling for job-spell fixed effects in matched employer-employee data by showing that job-to-job transition is non-random, which is inconsistent with the identification assumption of separate worker and firm fixed effects. They then argue that if the non-randomness of job transitions is time-invariant, it can be controlled for by job spell fixed effects.

for North-North and North-South offshoring (except EHMP 2014). This clearly shows that theories of North-North offshoring should be an important part of the literature. Second, most studies identify off within-firm changes over time (by using fixed effects or differencing), and show that the effects of offshoring on wages and employment choices happen within individual firms. Third, some weak evidence is emerging for the productivity effect emphasized in Grossman and Rossi-Hansberg (2008). E.g. Mion and Zhu (2013) show that, in some specifications, offshoring increases firms' survival probability; HJMX 2014 show that their coefficient estimates are smaller in magnitudes when they control for firms' uses of other inputs, such as capital, but these differences are small. Finally, few studies are about general-equilibrium effects. One study with general-equilibrium *flavor* is Amiti and Davis (2011). They show that changes in tariffs of an industry affect the average wages of the domestic firms in the same industry, although these effects are not statistically significant. Despite this progress, more work can be done, and should be done, to bring empirics and theory closer together.

On the other hand, the studies in waves 2 and 3 speak directly to the concern that the American middle class is being hollowed out, and that college degrees are losing their values in the global economy. This concern is driven by rapidly rising tuition and fees for U.S. universities and colleges (e.g. Krugman 2011),⁴⁷ and also by offshoring itself (see our discussion in section 1). The wave-2 and wave-3 studies clearly show that offshoring could bring higher wages for individual workers, especially those with college education. These results hold for both North-South and North-North offshoring, which is important, because most offshoring takes place

⁴⁷ An example of recent media discussions is "The log-on degree", the Economist magazine, March 14, 2015, pp. 29-30.

among Northern countries (see our discussions in section 2). However, this positive effect of offshoring on wages is missing from policy and public discussions.

To be clear, these positive wage effects only apply to the workers who remain employed; we take up the effects of offshoring on displacement and unemployment in section 5 below. For now, we examine whether, and how, the effects of offshoring vary across occupations.

4. The Differential Impact of Offshoring Across Occupations

How offshoring affects specific occupations concerns not only economists but also the public. In a front-page article on March 28, 2007, the Wall Street Journal warned that offshoring could

“...put as many as 40 million American jobs at risk of being shipped out of the country in the next decade or two. That's more than double the total of workers employed in manufacturing today.”

The concern stems from the belief that many occupations, such as computer programmers, graphic designers, bookkeeping, accounting and auditing clerks, and Yes, *Economists*, are “highly offshorable”.

The Wall Street Journal article attributes the 40-million estimate and the list of highly offshorable occupations to Blinder (2006, 2007)⁴⁸. However, Blinder (2006, 2007)’s estimates are based on subjective perceptions of what is offshorable, and something grounded in measurable labor market outcomes is preferable. Given the visibility and important policy

⁴⁸ Blinder and Krueger (2013) measure offshorability using household surveys. Some of their measures are based on self reporting while others classifications by professional coders. Correlation is high across these measures.

implications of this topic, we next survey studies that examine how the effects of offshoring on wages and employment vary with occupation characteristics. We organize our survey by the source of occupation-characteristics data.

4.1 The U.S. O*NET and Similar Data Sets

A widely used data set for occupation characteristics is the U.S. O*NET, which provides information on the knowledge, skills, and abilities of a particular occupation along with other on-the-job characteristics of the work environment.⁴⁹ One challenge in using the O*NET data is that any given occupation is described using a long list of characteristics that become unwieldy in a regression setting, largely due to collinearity. Autor, Levy and Murnane (2003), or ALM 2003, introduce a distinction between routine and non-routine tasks, which are summary characteristics constructed by reducing the large set of specific O*Net characteristics through principal component analysis (PCA). The routine/non-routine distinction and PCA are both widely used in subsequent studies.

EHMP 2014 find that the negative wage effect of low-income-country offshoring is especially pronounced for the workers whose occupations have high routine-task indices (see also sub-section 3.5.1). Here the construction of the routine-task index follows ALM 2003, and is the sum of routine-task indicators divided by the sum of routine- and non-routine task indicators. HJMX 2014 augment their main specification (see sub-section 3.5.2) with the (instrumented) interaction between occupation characteristics and offshoring. They find that, conditional on education, the workers suffer larger wage declines in response to offshoring if

⁴⁹ The O*NET data is continuously updated and has different versions. However, changes from one version to another mainly reflect changes in the underlying methodology or coverage. See also sub-section 4.2 below.

their occupations have high routineness, high exposure to job hazards, or high requirements for natural science (e.g. engineering, physics). In contrast, workers enjoy larger wage gains in response to offshoring if their occupations have high requirements for social sciences (e.g. economics) or communication skills. In these results the occupation characteristics are generated using PCA.

Several recent studies focus on the employment effects of offshoring. Criscuolo and Garicano (2010) study the role of licensing and membership requirements (e.g. lawyers have to be licensed but consultants do not). Licensing requirements raise the cost of offshoring these tasks. This means that the occupations without licensing requirements should see larger wage and employment losses relative to the occupations with such requirements.

To measure service offshoring Criscuolo and Garicano (2010) draw on UK surveys of the imports and exports of individual firms by service type for 2001-2007, and then they aggregate their data to industry-by-occupation level. The measure for licensing requirements is a dummy constructed from detailed descriptions of U.K. occupational requirements, similar to those in the U.S. O*NET. The interaction between the licensing-requirement dummy and offshoring is the main explanatory variable. The dependent variable is median wage or employment, and other control variables include occupation and industry fixed effects and indicators for educational requirements by occupation. This interaction term is positive and statistically significant, consistent with the hypothesis. In addition, offshoring has positive employment effects but negative wage effects for non-licensing occupations.

Ottaviano, Peri and Wright (2013), or OPW 2013, examine the employment effects of both offshoring and immigration. Their theoretical framework follows Grossman and Rossi-

Hansberg (2008). Low-skill tasks, or L-tasks, can be performed by 3 groups: native-born, immigrant, and offshore workers. They are all unskilled and perfect substitutes. All high-skill tasks are performed by native-born workers. Domestic firms discriminate between native-born and immigrant unskilled workers and pay them different wages. L-tasks can be ranked by its complexity. Immigrants have a comparative advantage for simple L-tasks, and offshoring costs are increasing in L-task complexity. OPW 2013 make additional assumptions for parameter values so that in equilibrium, immigrants perform the simple L-tasks, offshore workers perform intermediate while native-borns perform the complex. The model predicts that as offshoring cost falls, employment share falls for immigrants and native-borns but rises for offshore workers, and average complexity falls for the tasks performed by immigrants but rises for those by native-borns.⁵⁰

Data for employments of unskilled immigrant and native-born workers by industry come from U.S. Census and American Community Survey, 2000-2007. Employment for offshore workers is foreign employments of U.S. MNC affiliates plus imputed employments of their unaffiliated parties. For complexity, OPW 2013 calculate, for each worker, a single index using O*NET data for cognitive, communication, interactive, manual, and routine, and then average this index across immigrant and native-born workers within industry-year cells. This data is not available for offshore workers. In addition, OPW 2013 proxy for offshoring costs using average U.S. tariff rates, and construct a measure for immigration costs based on the supply-push measure of Card (2001).

⁵⁰ OPW 2013 also study how a fall in immigration costs affects employment shares and average complexity, as well as how immigration and offshoring costs affect employment levels. E.g. offshoring has no significant effects on the employment levels of immigrants and native-borns in the U.S.

For specification, each observation is one industry-year, and industry and year fixed effects are included. OPW 2013 first regress the employment shares of immigrant, native-born and offshore workers on offshoring and immigration costs. OPW 2013 then regress the average task indices for immigrants and native-borns on the employment shares of immigrant and offshore workers, where these employment shares are instrumented by offshoring and immigration costs. The empirical results are consistent with the model predictions.

Crino (2010) draws on U.S. industry-occupation data for 1997-2006 and uses the following two-step procedure to estimate the effects of service offshoring on employment. The first step involves estimation of the elasticity of employment with respect to service offshoring for all occupations. To implement this step Crino (2010) builds a production function where each industry uses, as variable inputs, all occupations plus energy and materials, etc. The occupations enter the production function in a nested structure, with the first tier being occupation groups (e.g. architecture and engineering occupations) and the second tier occupations (e.g. industrial engineers). Fixed inputs, on the other hand, enter the production function like Hicks-neutral productivity, and both capital and service offshoring are fixed inputs. However, material offshoring is variable input and not fixed input. The second step then correlates the estimated elasticities from the first step with occupational skill requirements and tradability.

Crino's (2010) measure of service and material offshoring is the same as Amiti and Wei (2005). For occupational skill Crino (2010) starts from individual data for schooling in the U.S. Census and then averages across individuals by occupation. For occupational tradability Crino (2010) uses the following data from O*NET: (a) routine cognitive tasks; (b) interactions with

computers and (c), face-to-face interactions; and (c). The first two increase tradability while the third decreases it.

Crino (2010) specifies the production function as translog, and derives estimation equations relating the shares of occupations in occupation-group wage bills and the shares of occupation groups in overall wage bill to service offshoring, plus other controls (e.g. average wages of occupations, material offshoring, etc.). These equations produce estimates for the elasticity of employment with respect to service offshoring by occupation and also by occupation group. Crino (2010) then shows that the occupations with high average skill are more likely to see their employments grow in response to service offshoring (i.e. positive employment elasticities). In addition, the occupations with high tradability are more likely to have negative employment elasticities with respect to service offshoring.

Comparing Criscuolo and Garicano (2010), OPW 2013, and Crino (2010), we note that they report mixed results for how offshoring affects employment levels. OPW 2013 find no effect, Criscuolo and Garicano (2010) report positive effects, while Crino (2010) finds positive effects for some occupations but negative effects for the others. We also note that all three studies use industry level data and take offshoring, both service and manufacturing, as exogenous. Our survey of section 3 shows that offshoring is at least partly driven by firms' and producers' choices, and that the literature has developed a number of tools for extracting exogenous variation in offshoring from the data. Below we will demonstrate that these tools can be applied to industry- and occupation-level data, and that doing so makes a difference for the results.

4.2 The German Qualification and Career Survey (QCS)

Unlike the U.S. O*NET, which focuses on the knowledge, skills and abilities required in an occupation, this data set reports the tools used by individual workers on their jobs (e.g. power tools; pencils; camera, video camera), and a given worker might use multiple tools. Researchers generally classify each tool use as a task characteristic, and then aggregate across individuals by occupation to construct occupational characteristics.⁵¹

Becker, Ekholm and Muendler (2013), or BEM 2013, use German firm-level data during 1998-2001 to study how offshoring affects the composition of the workforce of individual firms. BEM 2013 limit their sample to MNC plants, unlike the other papers we discuss in this survey,⁵² and measure offshoring as the ratio of MNC affiliate employment to total employment. In order to measure occupation and task characteristics using the QCS data, BEM 2013 first classify each tool use in the QCS data as routine or non-routine, and interactive or non-interactive (e.g. the use of a video camera is both non-routine and interactive). Then they calculate the numbers of non-routine and interactive uses by worker. BEM 2013 show that the routine/non-routine and interactive/non-interactive cuts are correlated with, but distinct from, the high-skill/low-skill cut. Next, BEM 2013 average these numbers across workers by occupation, and divide the occupational means by the max values across all occupations. This procedure produces a continuous measure for non-routineness and interactivity ranging from 0 to 1.

The regression specification features dependent variables that reflect the workforce composition of MNC plants: the wage bill shares of the workers who are high-skilled, or whose

⁵¹ Another difference with O*NET is that one could construct time-varying occupational characteristics from the QCS, since it was carried out in 4 waves (see, e.g., Spitz-Oener 2006). So far this feature of the QCS data has not been used to study how offshoring affects wages and employment.

⁵² In this sense, BEM (2013) also fit into the empirical literature on FDI and MNC's (e.g. Slaughter 2000, Head and Ries 2002, and Harrison and McMillan 2011).

jobs involve non-routine or interactive tasks. The main explanatory variable is offshoring. Given the panel data BEM 2013 considers both plant-level fixed effects and random effects.

BEM 2013 reports that high offshoring is associated with large shares of high-skilled workers. This result echoes the findings of the papers we surveyed in section 3, even though BEM 2013 uses a different data sample. BEM 2013 also shows that high offshoring is associated with large shares of non-routine-task workers and interactive-task workers.

One caveat with BEM 2013's results is that they take offshoring as exogenous, like Biscourp and Kramarz (2007). This issue is addressed in Baumgarten, Geishecker and Görg (2013), or BBG 2013, who study how the wage effects of offshoring vary with skill and occupational characteristics during 1991-2006. BBG 2013 follow BEM 2013 to construct non-routineness and interactivity from the QCS data. Like the studies surveyed in sub-section 3.5.1, BBG 2013 combine data on individuals' wages and other characteristics with occupation- and industry-level data on trade. Unlike the U.S. CPS data used in those studies, however, the data used in BBG 2013 is a German longitudinal household survey that consistently tracks individuals over time. This allows BBG 2013 to control for worker fixed effects in their estimation. On the other hand, BBG 2013 measure offshoring using the ratio of narrow offshoring to output.

BBG 2013 then regress individual workers' wages on offshoring and its interaction with non-routineness and interactivity, plus other controls, and they split the sample between high- and low-skilled workers. BBG 2013 do the estimation using both cross-industry and cross-occupation variation, as in EHMP 2014. BBG 2013 then construct the WES and transport-cost instruments of HJMX 2014 at industry- and occupation-levels.

BBG 2013 find that using cross-industry variation, offshoring reduces the wages of unskilled workers. In addition, controlling for endogeneity is important: the magnitude of the wage effect of offshoring is 3-5 times larger under IV than under OLS. The interaction between offshoring and occupational characteristics, however, is not significant. Using cross-occupation variation, BBG 2013 find that the interaction term is positive and significant, especially for the sample of high-skilled workers. In other words, the high-skilled workers whose jobs involve high interactivity and non-routine content gain more from offshoring than other high-skilled workers.

To summarize, the studies we have surveyed in section 4 have reached the following consensus. When offshoring increases, the occupations that are non-routine, with licensing requirements, or intensive in communications, languages and face-to-face interactions, see their wages and employments rise, relative to other occupations, conditional on skill. These findings have implications for recent policy initiatives in the U.S. to emphasize STEM (Science, Technology, Engineering, and Math) in education. While entry-level wage *levels* for college graduates with STEM majors tend to be higher on average,⁵³ we see no evidence that knowledge in science, technology, or engineering helps with faster wage *growth* in response to offshoring. In fact, HJMX 2014 show that knowledge in these areas is negatively correlated with wage growth. In contrast, skills in communications, languages and inter-personal interactions, which are strongly correlated with faster wage growth according to most studies we survey, are notably absent from the discussions about how globalization forces should affect educational policy.

⁵³ This is less true for science majors. See, e.g. <http://www.theatlantic.com/business/archive/2013/09/why-the-s-in-stem-is-overrated/279931/>.

On the other hand, speaking to theory, the empirical studies have clearly established the heterogeneity of the effects of offshoring across occupations. This heterogeneity is for both skilled intensities and the occupational characteristics that are plausibly related to offshoring costs (e.g. licensing requirements, face-to-face interactions). The implication, then, is that variations across tasks in factor uses and offshoring costs are both important features of the data. Beyond this, however, many questions remain open for future research. For example, the empirical studies do not necessarily shed light on the specific channels through which offshoring affects wages. Many theoretical mechanisms we surveyed in sub-section 3.2 are general equilibrium and work between industries or even between sectors. In addition, these studies do not allow us to distinguish why particular tasks are offshored, that is, whether the differences reflect underlying comparative advantage at the task level or simply differences in the costs of offshoring. More specifically, why do workers with routine occupations suffer more from offshoring? Is it because routine tasks require limited skill to perform, or because they are easy to coordinate over long distances? These questions await future research.

5. Offshoring, displacement and unemployment

The empirical work we have surveyed so far all relates to the theoretical literature surveyed in subsections 3.1-3.2, general equilibrium models that assume full employment. As a result, this body of work is silent about whether, and how much, offshoring affects unemployment rates and the earnings of displaced workers. There is a broad public perception that offshoring leads to significant displacement, with associated unemployment and lasting impacts on workers.

We begin this section with a brief review of recent theoretical work that focuses on trade with unemployment. We turn next to some empirics on displaced workers. We first briefly explain the approach taken in the labor literature to study displacement and then review existing empirical papers on trade and displacement.

5.1 Theories for offshoring and unemployment

A growing theoretical literature suggests that labor market rigidities are both an important source of comparative advantage, and a cause of unemployment outcomes. The early literature relied on traditional trade models such as Heckscher-Ohlin-Samuelson models or Ricardian models with labor market frictions of various kinds: minimum wages (Brecher 1974, Davis 1998), incomplete labor contracts (Matusz 1985), search and matching costs (Davidson, Martin and Matusz 1999), efficiency wages (Copeland 1989, Brecher 1992) and fair wages (Agell and Lundborg 1995). Recently a new wave of research has emerged where labor market imperfections are incorporated into trade models with firm heterogeneity. The imperfections modeled include rent sharing (Amiti and Davis 2011), efficiency wages (Davis and Harrigan 2011), fair wages (Egger and Kreckemeier 2009) and search and matching costs (Davidson, Matusz and Shevchenko 2008, Helpman, Itskhoki and Redding 2010, Felbermayr, Prat and Schmerer 2011).

A number of theoretical papers have a specific focus on offshoring with imperfections in the labor market. Mitra and Ranjan (2010) set up a two-sector general equilibrium model with search frictions in the labor market. Offshoring of labor activities leads to a productivity enhancing effect akin to Grossman and Rossi-Hansberg (2008), which is due to

complementarity between the offshored input and the domestically procured input. However, in the setting of Mitra and Ranjan the impact of offshoring is an increase in wages and a reduction in unemployment if there is sufficient intersectoral mobility. In the absence of search frictions there would only be a wage increase.

If offshored inputs and domestic labor are perfect substitutes there would be no productivity effect of offshoring and no reduction in unemployment in the framework of Mitra and Ranjan (2010). However, Ranjan (2013) shows that even when offshored inputs and domestic labor are perfect substitutes there may be an unemployment reducing effect of offshoring. Ranjan (2013) builds a search model with collective bargaining resembling the institutional framework of many European labor markets. Wages are set by unions after which firms set employment. In this model the possibility of offshoring (lower offshoring costs) induces unions to set lower wages, which leads to higher employment levels chosen by the firms. It is shown that the relationship between the cost of offshoring and unemployment is non-monotonic as unemployment falls with lower offshoring costs for high initial costs of offshoring, while unemployment rises when the cost of offshoring becomes sufficiently low. If, in contrast, wages are set through individual bargaining, resembling more the labor market in the U.S., offshoring increases unemployment. In a calibration exercise for Sweden Ranjan (2013) shows that a reduction in the cost of offshoring from the current level reduces unemployment.

Sethupathy (2013) sets up a model with heterogeneous firms, productivity effects of task offshoring a la Grossman and Rossi-Hansberg (2008) and search costs and bargaining in the labor market. In addition, firms have endogenous markups due to a quasi-linear demand

function leading to variable firm-level rents. In this model offshoring leads to lower marginal costs of production which increases output, markups, profitability and wages through rent sharing. This offshoring effect is stronger for more productive firms and offshoring brings about a reallocation of production towards more productive firms. Employment effects are ambiguous for the more productive offshoring firms as the positive productivity effect counteracts the direct negative employment effect from offshoring. The least productive firms, on the other hand, contract and reduce employment. Sethupathy (2013) tests these predictions using firm level data for the U.S. and the Mexican peso depreciation in 1994 as a natural experiment. It is found that profitability and domestic wages increased for firms initially offshoring to Mexico relative to other offshoring firms, while no evidence is found for differential employment effects between the two sets of firms.

Egger, Kreickemeier and Wrona (2013) also build a model with firm heterogeneity and task offshoring. To capture unemployment effects they extend the model to include labor market imperfections through a fair wage effort mechanism. They find that offshoring has a non-monotonic effect on unemployment such that unemployment is lower than in autarky when only few firms offshore while the opposite holds when many firms offshore. In a calibration exercise for Germany they find that offshoring has reduced unemployment somewhat.

The models reviewed above offer explanations for how offshoring is related to equilibrium unemployment, but they are silent about the relationship between offshoring and employment volatility. Bergin, Feenstra and Hanson (2011) develops a North-South trade model with an offshoring sector with heterogeneous firms and a continuum of products and a

numeraire sector. Uncertainty is introduced into the model by assuming that the economy may be in one of several states. When North experiences higher demand more firms will offshore since domestic wages are procyclical, so offshoring will counteract the higher demand for labor. This is the extensive margin of offshoring. By contrast, there is no counteracting effect on the increased offshoring induced demand for labor in South, so the model explains higher employment volatility in South relative to North. Results from simulations of the model are consistent with data for Mexican intermediate goods exports to the U.S.

Related to this, Karabay and McLaren (2010) show in a model with uncertainty, incomplete labor contracts and search how workers and employers seek to share risks by smoothing out shocks to wages and entering long term employment relationships. In their model offshoring is modeled as international integration of labor markets, and they show that offshoring may lead to greater volatility of wages by weakening employment relationships.

5.2 Empirics on offshoring and displacement

The theoretical papers reviewed above mainly study long run implications of trade liberalization and access to new offshoring opportunities. That is, they compare equilibrium outcomes before and after a liberalization episode. However, transition to new equilibrium outcomes often entails adjustment costs for workers in the form of spells of unemployment and lower reemployment wages due to the loss of sector or occupation specific human capital. These adjustment costs should be held up against the overall gains from trade, and often much attention is given these costs by policy makers and commentators.

A growing literature structurally estimates adjustment costs from trade liberalization typically using models with sector-specific human capital or other frictions in the labor market (e.g. Kambourov 2009, Artuc, Chaudhuri and McLaren 2010, Cosar 2013, Cosar, Guner and Tybout 2015, Dix-Carneiro 2014 and Ashournia 2015), but none of the papers in this literature focus on offshoring.

We next review the literature on reduced form empirical approaches to offshoring and employment outcomes. Again, matched worker-firm data provide a unique perspective on displacement because it provides (a) the ability to understand impacts on entire cohorts of workers, both those who remain employed by the firm and those who are displaced; and (b) the ability to follow workers post-displacement. It also provides perspectives on whether displacement due to offshoring might be more severe than other forms of displacement.

One way to investigate the relationship between offshoring and employment outcomes for workers is to estimate the overall long run effect on labor market earnings of initially being in a firm that for exogenous reasons increases offshoring relative to being in a firm that does not increase offshoring. By looking at changes in labor market earnings over several years, wage effects, unemployment effects and firm, occupation and industry switching are accounted for. Autor, Dorn, Hanson and Song (2014) and HJMX 2014 take such an approach to estimate the impact of Chinese import penetration on American workers, and the impact of offshoring on Danish workers, respectively.⁵⁴ Here we outline the approach taken in HJMX 2014, since they look at offshoring and have access to matched worker-firm data.

⁵⁴ Walker (2013) uses a similar approach to estimate the transitional costs of sectoral reallocation of workers from environmental regulation.

HJMX 2014 define cohorts of workers as those employed in a particular firm in a base year, then track these cohorts over five years irrespective of whether the workers stay or leave the firm after the first year. For the fixed composition of workers in each cohort, the average earnings are calculated in all five years and changes in these average earnings are then related to exogenous offshoring shocks to the firm in the base year. Included as control variables are cohort specific characteristics, year effects and cohort fixed effects.

From the estimated model the accumulated earnings losses from offshoring shocks are calculated as the present discounted value of earnings changes over the five-year period. HJMX 2014 find that if the firm doubles offshoring the average low-skilled worker incurs a loss of 4.2% of their pre-offshoring labor earnings over the ensuing five years. This loss measures any within job-spell changes in wages, wage changes in new jobs and losses due to time spent in unemployment. In contrast, the average high-skilled worker gains 4.9% of their pre-offshoring earnings. That is, even if some high-skilled workers lose their job because offshoring, this is not enough to outweigh the wage gains experienced by the average high-skilled worker.

The advantage of the cohort approach is that it estimates the total wage/earnings effects of offshoring, including the effects within job spells, for all workers in a cohort. This includes displaced and unemployed workers, and workers who switch to new firms or new industries. This estimate is free from any issues related to the selection of displaced workers since the cohort is constructed *prior to* displacement. Therefore, the cohort approach represents progress for the identification-inference trade-off that we discussed at the end of section 4, and may be a useful tool for future research.

A complementary approach estimates the earning losses by displaced workers, which may be of particular interest to commentators and policy makers. There is a long tradition for estimating earnings losses from displacement in the labor literature, see e.g. Jacobson, Lalonde and Sullivan (1993) and Kletzer (1998). One of the challenges of the displacement literature is to separate quits from layoffs, and this is most typically done by focusing on mass layoff events, where a substantial portion of workers separate from the firm (mass layoff events are most commonly defined as a separation rate of at least 30 percent). Jacobson, Lalonde and Sullivan (1993) have access to data for a large number of workers in Pennsylvania, and find that high-tenure workers experience substantial earnings losses (around 25 percent of predisplacement earnings) when they leave their jobs due to mass layoffs compared with non-displaced workers. These losses are long-term with little evidence of recovery after the third year and arise even prior to workers' separations. Similar results for the U.S. have more recently been found by e.g. Couch and Placzek (2010). There are also long-term earnings losses from displacement in Europe, but most studies find more modest effects, see for example Eliason and Storrie (2006) for evidence from Sweden and Huttunen, Møen and Salvanes (2011) for earnings losses of displaced Norwegian workers.

As mentioned above, another challenge of the displacement literature is the potentially non-random selection of laid off workers in each firm. Firms are likely to lay off workers who perform poorly around the time of separation. The ability to use trade or offshoring data could be useful in this regard because it provides a labor demand shock that is exogenous to the firm. Hummels, Munch and Xiang (2013) use the Danish matched worker-firm data of HJMX (2014) and the world export supply instrument discussed in section 3.5 to construct firm-specific

offshoring shocks. This enables them to compare earnings of workers who are displaced due to offshoring shocks (defined as an increase of at least 10 percent in predicted firm-level offshoring) with workers displaced in other mass layoff events. That is, they extend the Jacobson, Lalonde and Sullivan (1993) specification, such that earnings losses of the two types of displaced workers are estimated separately and compared.

They find that low-skilled workers displaced from firms that are hit by an offshoring shock lose 21 percent of predisplacement earnings in the year after displacement, and five years after displacement these workers are still substantially below their predisplacement earnings. By contrast, other displaced low-skilled workers lose 15 percent of pre-displacement earnings in the year after displacement and they almost recover to the predisplacement level after five years. The corresponding earnings losses for high-skilled workers are 15 and 7 percent for those displaced due to offshoring and other mass layoff events respectively. The larger earnings losses suffered for workers displaced in firms hit by offshoring shocks are partly attributed to a higher incidence of unemployment and higher propensity to switch industry when reemployed suggesting that their labor market options are worsened. This is consistent with the view that globalization leads to economy-wide reductions in demand for certain tasks. For example, if domestic competition drives a firm out of business, local firms may absorb displaced workers doing tasks very similar to what they had previously been doing. However, displacement due to offshoring may leave workers with no opportunities for using the same skills.

Another approach to examine the link between offshoring and employment outcomes is to analyze how offshoring affects the probability of job separations. A small literature has

pursued this question by using worker level data, but where offshoring is measured at the industry level. Egger, Pfaffermayr and Weber (2007) use data for Austrian male workers and estimate a multinomial logit model for transitions between unemployment, out of the labor force and employment in four different sectors. They find that rising industry offshoring lowers the probability of staying in or changing to a job in the manufacturing sector but they are unable to obtain results for transitions to unemployment. Geishecker (2008) studies the impact of industry level offshoring on the hazard rate of exiting employment for German workers and finds that offshoring lowers employment security irrespective of individual educational attainment. Munch (2010) uses Danish data and estimates a competing job risks duration model distinguishing between transitions into a new job or unemployment. He finds that offshoring increases the risk of becoming unemployed for low-skilled workers and increases the probability of changing job for high-skilled workers.

5.3 Empirics on Offshoring, Labor Demand Elasticities and Volatility

Another aspect of the link between offshoring and employment outcomes is how labor demand elasticities are affected. Rodrik (1997) argues that increased international mobility of production puts especially low-skilled labor in different countries into competition with one another. As a result, labor demand elasticities increase, which may have several implications for domestic labor. First, the incidence of costs associated with changes in the labor market such as payroll taxes or higher safety standards will to a greater extent be borne by workers. Second, demand shocks should be felt more strongly by workers as wage and employment volatility increases. Third, the bargaining power of workers will fall and their share of rents will drop.

Kramarz (2008) uses French matched employer-employee data and studies a two-stage bargaining game. Firms have market power in the product market. At the second stage, the firm and union bargain over both wage and employment and decide how to split the rent. The firm's outside option depends on how much it offshores. At the first stage, the firm optimally chooses offshoring, taking into account the effect of offshoring on the outcome of subsequent bargaining. Under certain parameter values, an increase in offshoring reduces the rent that can be shared with the union during bargaining. This pushes the firms with lower bargaining power to offshore more, which, in turn, lowers employment and has ambiguous effects on wages.

Kramarz (2008) merges the firm-level data in Biscourp and Kramarz (2007) with additional worker data from France, creating a matched employer-employee data set spanning 1986-92. His main specification is in the framework of (2), where offshoring is measured in the same way as Biscourp and Kramarz (2007), and worker i controls are used in addition to worker fixed effects. The main explanatory variables are rent-per-worker and bargaining regime. Rent-per-worker is constructed from the estimated firm fixed effects of a wage Mincer regression with separate worker and firm fixed effects. For a French firm j importing products of industry k , Kramarz (2008) instruments rent-per-worker using lagged average prices in industry k of U.S. exporters. Bargaining-regime is a series of dummies indicating whether or not the firms were engaged in wage or employment bargaining in 1992. Kramarz (2008) interacts bargaining-regime with offshoring and rent-per-worker. Offshoring is not instrumented.

Kramarz (2008) finds that wages are high in the firms that bargain on employment and have high rent-per-worker, and the offshoring variables do not have statistically significant effects on wages. The interpretation is that firms that bargain on employment face strong

unions. Kramarz (2008) then show that these firms experienced decreases in employment and increases in offshoring in 1986-92.

Sly and Soderbery (2014) explore a specific channel through which firms producing automobiles might exploit offshoring to limit the bargaining power of workers. Within the same firm, different car models command different product markups. Labor unions with bargaining power in the US might successfully extract some of the rent from these model lines. However, if the firm sorts high markup vehicle production into Mexico and lower markup vehicles into the US, they can lower significantly lower the overall impact of bargaining power on workers on the distribution of rents while not affecting the aggregate volume of offshoring. They use data on the production location of high- and low-markup vehicles to confirm that sourcing patterns in North America are used in precisely this way.

Have labor demand elasticities increased as a consequence of international trade and offshoring? Slaughter (2001) uses U.S. industry level data for 1961 to 1991 and finds that demand for production labor has become more elastic in most manufacturing industries, but he does not find strong support for the suggestion that this is caused by international trade or offshoring. Hijzen and Swaim (2010) use industry-level data for 11 OECD countries over the period 1980-2002. They also find that labor demand elasticities in the manufacturing sector have increased. For a shorter time period but for 17 OECD countries they construct Feenstra and Hanson (1997) offshoring measures as the share of imported intermediate inputs in domestic production. They document that offshoring is positively correlated with labor demand elasticities in the cross section but not over time. Senses (2010) uses plant-level data for the U.S. manufacturing sector in 1972-2001 to investigate the link between offshoring and labor

demand elasticities. The plant level data is used to estimate labor demand elasticities for each year and industry, and they are then related to several measures of offshoring at the industry level. She finds robust evidence for increases in offshoring to significantly contributing to increases in labor demand elasticities.

Kurz and Senses (2016) examine if increased offshoring leads to changes in employment volatility in the U.S. as suggested by Rodrik (1997) and the theoretical model by Bergin, Feenstra and Hanson (2011) reviewed in section 4.1. In this model, a positive demand shock in North will trigger adjustments along the extensive offshoring margin (multinational production will be offshored to South), which will lead to relatively lower employment volatility in North. As explained above, Rodrik (1997) argues that offshoring's expanding impact on the elasticity of labor demand will, in contrast, increase employment volatility, so there are opposing forces on volatility. Kurz and Senses (2016) use data for all U.S. manufacturing firms and their individual trade transactions of imports and exports at the product and origin level for 1991-2005 and calculate firm-level employment volatility as the standard deviation of the (residual) employment growth rates. They find that relative to non-trading firms, firms that only export and firms that both export and import exhibit less employment volatility, while firms that import (or offshore) are more volatile.

Krishna and Senses (2014) study a related question, namely how increased trade affects labor income risk in the U.S. Again, trade may increase labor income risk through higher labor demand elasticities. They use longitudinal worker-level data for the U.S. covering the years 1993-2003 to calculate industry-level labor income risk as the permanent part of the residual in a Mincer-like labor income equation. They then relate this measure to industry-level import

competition and find that increased import competition has a substantial positive causal effect on labor income risk. In an extension they include a measure for industry-level offshoring and find that an increase in offshoring is associated with a decline in income risk. As explained above, this is consistent with the predictions of Bergin, Feenstra and Hanson (2011).

5.4 Offshoring, unemployment and training

The previous section has shown that workers exposed to offshoring experience substantial income losses due to unemployment, so labor market policies targeted towards these workers may be called for. One possible policy is to offer retraining of displaced workers. Very few studies have examined whether retraining could potentially be particularly useful in helping workers displaced due to offshoring back to work. Hummels, Munch, Skipper and Xiang (2012) combine the Danish matched worker-firm data with detailed records for participation in vocational and post-secondary training programs to examine the relationship between offshoring, displacement and training. The Danish training system is heavily subsidized with a high incidence of training as a result, but the training courses are not targeted towards certain types of workers. Hummels, Munch, Skipper and Xiang (2012) use a specification similar to Jacobson, Lalonde and Sullivan (1993) but with earnings replaced with the training take up rate as the dependent variable. They find that workers displaced from firms hit by an offshoring shock enroll in training courses at higher rates than workers displaced from other firms. Again, this suggests that there is a sector- or economy-wide component in offshoring induced changes in labor demand, and so labor market programs targeted towards these workers may be called for.

Park (2012) examines outcomes for participants in the Trade Adjustment Assistance Program (TAA) in the U.S. This program is of particular interest because TAA applications specifically pinpoint job loss from offshoring and import competition. She defines successful training as an instance when a participant who received training in skills for a certain occupation found a job in the same occupation, i.e, the skills acquisition likely was the cause for reemployment. Controlling for individual characteristics she then finds that successful training reduces the earnings loss from displacement relative to participants who did not obtain a match between the occupation of the training course and the subsequent job. These findings highlight the importance of picking the right occupational training course.

6. Conclusion

In this review we have focused on four major issues related to offshoring and labor markets: measurement of offshoring; empirical work that addresses offshoring, labor demand and worker wages; estimates of differential labor market impacts across occupations; and the consequences of offshoring for displacement, volatility, and retraining. Below we summarize major lessons learned, and outline key work that has yet to be done.

Many measurement papers use industry level input-output tables combined with trade data to capture the mix of inputs used by a firm and to understand shocks to the foreign/domestic mix of those inputs. Other papers use data on the activity of multinational enterprises and their foreign affiliates to capture offshoring. Still others employ data on imported input purchases at the firm level. The findings on the measurement side are fairly straightforward. Production sharing is increasing in importance. It involves both North-North

and North-South country pairs, varies considerably across industries, and it is sensitive to both cross-section and time series variation in trade costs. Papers that employ firm-level import data point to significant within-industry heterogeneity in input purchases, showing the limitations of industry level analysis and identification. However, these studies are considerably limited in country scope and duration. Ultimately, a major weakness of the measurement literature is the difficulty in finding a close match between data and the conceptual idea of offshoring.

Our survey describes a variety of theoretical mechanisms through which offshoring could affect labor demand and wages, including changes in relative skill demand within industries, and changes in productivity at the firm level. It is incumbent on empirical work to sort out these mechanisms, and the theoretical literature has several useful messages for empiricists. First, loose discussions about the impact of “trade” on firms and workers mix up two very different effects. Import competition is generally a negative shock for import-competing firms and the workers they intensively employ. Offshoring is likely a positive shock for firms (e.g. the productivity effect of Grossman and Rossi-Hansberg 2008), and the effects for workers depend on the model at hand.

Second, firms choose whether, and how much, to offshore as a function of both exogenous forces and the internal capabilities of the firm. To the extent that wages and other labor market outcomes are also a function of those internal capabilities, it is important to exploit exogenous sources of variation in offshoring in order to properly identify the impact on workers.

Third, papers in the theoretical literature differ on what drives differences in offshorability across tasks. Grossman and Rossi-Hansberg (2008, 2012) assume tasks differ in the cost of offshoring, but not in their skill intensity, *within a given sector*. Feenstra and Hanson (1996, 1997) and Burstein and Vogel (2010) make the opposite assumptions. While these choices surely reflect modeling needs and differing analytical focus, they also point to our ignorance about the most fundamental elements of offshoring. Empirical work to date has not gone far enough in clearing up this ignorance.

We review three waves of empirical work on offshoring, labor demand and wages, corresponding to analysis at the level of industries, of firms, and of workers. A common finding of the first wave is that offshoring increases relative demand for skilled labor within industries over time. These findings are consistent with the view that offshoring allows countries to specialize, within industries, along lines of factor abundance.⁵⁵ The second wave also finds that offshoring has a significant impact on wages and employment, but observed at the firm level, and with more subtle and varied effects. The third wave turns to worker level data, finding significant effects on individuals' wages. Here, the specifics of the findings depend on measurement of offshoring (e.g. imports vs. MNC affiliate employment) and identification strategy (e.g. OLS vs. IV).

We also highlighted work that addresses the differential effects of offshoring across occupations. The literature has shown us that: (1) workers with routine occupations suffer more from offshoring in terms of wages and employment; (2) those with communication-

⁵⁵ However, they cannot be used to rule out other explanations. For example, offshoring may affect productivity within the firm. If that productivity is factor biased, as in Burstein and Vogel (2010), it would result in changes in skill demand even if task specialization were not based on factor abundance.

intensive or interactive occupations gain more from offshoring in terms of wages and employment; and (2) routineness, communication/interactivity, and licensing requirements may all be useful proxy measures that capture differences across occupations in the cost of offshoring. Taken together, the rich heterogeneity of the wage effects of offshoring, with respect to skill and occupational characteristics, suggests that offshoring plays an important role in income distribution and changes in income inequality. In this sense, the studies we have surveyed speak directly to the literature on globalization and income inequality (e.g. Goldberg and Pavcnik 2007), and complements the literature on gains from trade (e.g. Costinot and Rodriguez-Clare 2014). In addition, these studies contribute to public and policy discussions about globalization, income inequality, and returns to STEM and other college majors, as we argue at the end of sections 3 and 4.

Apart from baseline findings this empirical literature highlights several important estimation challenges. The first theme is the need to address the endogeneity of offshoring, especially when firm-level data is used. One approach uses instruments that reflect shocks to foreign supply or the cost of trading inputs, as in HJMX 2014 and Liu and Trefler (2011). Another approach uses exogenous policy changes as natural experiments, as in Amiti and Davis (2011).

A second theme is the trade-off between identification and inference, associated with the use of more and more dis-aggregated data. For example, by using matched employer-employee data, HJMX 2014 identifies the causal effects of offshoring on individuals' wages, but their sample is limited to the manufacturing sector. In comparison, by using the publically available CPS data, EHMP 2014 incorporates service industries into their sample and captures

some of the between-industry and between-occupation effects of offshoring. This identification-inference trade-off is likely to challenge future research.⁵⁶

We can also see a number of open questions that might be fruitful areas for future research. For example, these results do not necessarily shed light on the specific channels through which offshoring affects wages. Many theoretical mechanisms we surveyed in sub-section 3.2 are general equilibrium and work between industries or even between sectors. In addition, these results do not allow us to distinguish why particular tasks are offshored, that is, whether the differences reflect underlying comparative advantage at the task level or simply differences in the costs of offshoring. More specifically, why do workers with routine occupations suffer more from offshoring? Is it because routine tasks require limited skill to perform, or because they are easy to coordinate over long distances?

Finally, we turn to work focused on offshoring and displacement. While many theories of offshoring focus on long run effects, public attention is often on short run adjustment costs. There are two approaches to identifying these costs. One focuses on the differences between displaced and non-displaced workers, in the manner of Jacobson, Lalonde and Sullivan (1993). The key challenge for this approach is that workers might not be displaced randomly. To circumvent the selection issue, recent work has developed a cohort approach (see sub-section 5.2), following wage trajectories for an entire cohort of workers employed in a firm prior to an offshoring shock. Because the composition of a cohort is fixed by construction, the cohort approach captures the overall wage effects of offshoring, both within job spells and through

⁵⁶ Autor, Dorn and Hanson (2013) study the effects of U.S. imports from China on U.S. labor market, and have struck a beautiful balance between identification (their IV is similar to HJMX 20142014) and inference (they use industry-level data).

displacement and job transition. In this sense, the cohort approach is progress for the identification-inference trade-off that we discussed previously, and may be a useful tool for future research. However, the cohort approach does not answer the question about how much displaced workers suffer relative to the other workers within a cohort, a question many policy makers might be interested in.

Regrettably, the literature has just begun to scratch the surface of some important questions one might ask about offshoring. First, more research is needed to understand how worker training might mitigate the effects of offshoring. Researchers are faced with two important challenges in making progress on that front. The data requirements are onerous (observing wage and training data for workers who are subject to offshoring shocks) and selection problems (which workers select into displacement and training) are severe. Second, offshoring leads to a reallocation of work within and between firms and it is important to better understand this reallocation process. What are the barriers to reallocation? What policies can be pursued to minimize earnings losses of displaced workers? Answers to such questions might be provided by structurally estimating models with barriers to reallocation, but structural labor market estimation focused on offshoring is missing from this literature.

Nearly twenty years have passed since the initial work on offshoring. In that time we have seen tremendous progress in theory, measurement, and tightly identified estimation. Yet this review underscores that researchers still have a long way to go.

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Table 1 Offshoring and Wages: Data, Measurement and Identification (Sections 3.3 through Section 4)

Paper	Status	Data	Major Policy Change	IV	Measure of Offshoring
Section 3.3 Industry-level Data					
Feenstra-Hanson 97	JIE	Mexico's Industrial Census. 1975-88	Trade & Investment Policy Change, 1980s	Distance to U.S. border	No. Foreign plants divided by No. Domestic plants
Feenstra-Hanson 99	QJE	U.S. I/O Table, Census of Manuf., NBER prod. & trade data. 1979-1990	N.A.	N.A.	Broad & Narrow Offshoring (constructed from Input-Output tables, based on the Proportionality Assumption)
Hsieh-Woo 05	AER shorter paper	H.K. Pop. Census & Annual Survey of Industrial Production. 1976-1996.	China's Opening to Trade, 1981	labor/skilled-labor share in 1976	Similar to Feenstra-Hanson 99, but Restricted to Imports from China
Amiti-Wei 05	working paper	U.S. I/O Table, IMF BOP yearbooks. 1992-2000.	N.A.	N.A.	Distinguishes Service vs. Material Off.; Both Similar to Feenstra-Hanson 99
Amiti-Wei 09	Book Chapter	U.S. I/O Table, IMF BOP yearbooks. 1992-2000	N.A.	N.A.	Same as Amiti-Wei 05

Table 1 Offshoring and Wages: Data, Measurement and Identification (Sections 3.3 through Section 4), Continued

Paper	Status	Data	Major Policy Change	IV	Measure of Offshoring
Section 3.4 Firm-level Data					
Biscourp-Kramarz 07	JIE	French firm level data. 1986/87-1991/92.	N.A.	N.A.	Manufacturing Firms' Imports; Broad & Narrow Offshoring
Mion-Zhu 13	JIE	Belgium firm level data. 1996-2007.	N.A.	Trade weighted tariffs and exch. rates, weights = 1-year lagged import values.	Same as Biscourp-Kramarz 07.
Amiti-Davis 11	ReStud	Indonesian firm level data. 1991-2000.	Trade Liberalization (mainly tariff cuts) in 1990's	unskilled-labor share in 1991, dummies for non-tariff barrier and for products excluded from tariff cuts	weighted average of industry tariff rates, weights = input shares from I/O table

Table 1 Offshoring and Wages: Data, Measurement and Identification (Sections 3.3 through Section 4), Continued

Paper	Status	Data	Major Policy Change	IV	Measure of Offshoring
<u>Section 3.5.1 Publically Available Worker Data</u>					
Liu-Trefler 08	working paper	U.S. CPS, BEA data for trade between unaffiliated parties. 1995-2006.	China and India's liberalizations, early 1990's	U.S. Imports from G8 Countries	Imports of Other Private Services from China & India, between Unaffiliated Parties
Ebenstein-Harrison-McMillan-Phillips 14	ReStat	U.S. CPS, BEA data for trade and MNC affiliate employment. 1984-2002.	N.A.	N.A.	Employments of Foreign Affiliates of U.S. Multi-nationals
Liu-Trefler 11	working paper	U.S. CPS, BEA data for trade between unaffiliated parties. 1995-2006.	China and India's liberalizations, early 1990's	GDP-per-capita & Its Coefficient Estimate in Gravity Equation	Imports of Other Private Services from China & India, between Unaffiliated Parties

Table 1 Offshoring and Wages: Data, Measurement and Identification (Sections 3.3 through Section 4), Continued

Paper	Status	Data	Major Policy Change	IV	Measure of Offshoring
Section 3.5.2 Matched Employee-Employer Data					
Hummels-Jørgensen-Munch-Xiang 14	AER	Danish matched employer-employee data. 1995-2006.	N.A.	Source Country Exports to (Imports from) World Minus Denmark. Transport costs.	Manufacturing Firms' Imports; Broad and Narrow Offshoring
Martins-Opromolla 09	working paper	Portugese matched employer-employee data. 1995-2005.	N.A.	N.A.	Manufacturing Firms' Imports. Broad Offshoring only .
Kramarz 08	working paper	French matched employer-employee data. 1986-1992.	Single Market Program 1988	Lagged U.S. Export Prices	Manufacturing Firms' Imports; Broad & Narrow Offshoring

Table 1 Offshoring and Wages: Data, Measurement and Identification (Sections 3.3 through Section 4), Continued

Paper	Status	Data	Major Policy Change	IV	Measure of Offshoring
<u>Section 4 Variation of the Effects of Offshoring Across Occupations</u>					
Criscuolo-Garicano 10	AER P&P	U.K. surveys of service trade and occupational requirements. 01-07.	N.A.	N.A.	Firms' Imports of Services
Ottaviano-Peri-Wright 13	AER	U.S. Census and American Community Survey, BEA data for MNC affiliate employment, and O*NET. 2000-2007.	N.A.	N.A.	Narrow Offshoring; Employments of Foreign Affiliates of U.S. Multinationals
Crino 10	ReStud	U.S. Census, BEA data for trade between unaffiliated parties, BLS Occupational Employment Statistics, O*NET. 1997-2006.	N.A.	N.A.	Same as Amiti-Wei 05
Becker-Ekholm-Muendler 13	JIE	German firm-level data and QCS. 1998-2001.	N.A.	N.A.	Employments of Foreign Affiliates of German Multinationals
Baumgarten-Geishecker-Görg 13	EER	German Soio-Economic Panel and QCS. 1991-2006.	N.A.	Same as Hummels-Jørgensen-Munch-Xiang 13, but at industry- and occupation-levels	Narrow offshoring

Table 2 Offshoring and Wages: Findings (Sections 3.3 through Section 4)

Paper	Measure of Offshoring	Sample Mean/Median/Range	Where to Where	If Offshoring Rises by 10% (see p27 or Table Footnote)
Section 3.3 Industry-level Data				
Feenstra-Hanson 97	No. Foreign plants divided by No. Domestic plants	[0, 0.07]	U.S. to Mexico	Share of non-prod. workers in wage bill rises by 0.0069, for average Mexican state (Table 4, column 1)
Feenstra-Hanson 99	Broad & Narrow Offshoring	Narrow (broad) has mean of 0.027-0.044 (0.063-0.097)	U.S. to World	Share of non-prod. workers in wage bill rises by 0.00064, for average U.S. mfg. industry (Table III, column 2)
Hsieh-Woo 05	Feenstra-Hanson 99, restricted to Imports from China	[0.1, 0.6]	H.K. to China	Share of skilled labor in wage bill rises by 2.7%, or 0.027 log points, for average H.K. industry (Table 4, column 2)
Amiti-Wei 05	Feenstra-Hanson 99, Distinguishes Service vs. Material Off.	Service (material) has range [0.0018,0.0029] ([0.12,0.17])	U.S. to World	Value-added per worker rises by 0.01%, or 0.0001 log points, for average U.S. industry (Table 6, column 3)
Amiti-Wei 09	Same as above	Same as above	Same as above	Employment falls by 0.006%, or 0.00006 log points, for average U.S. industry (Table 6, column 3)

Table 2 Offshoring and Wages: Findings (Sections 3.3 through Section 4)

Paper	Measure of Offshoring	Sample Mean/Median/Range	Where to Where	If Offshoring Rises by 10% (see p27 or Table Footnote)
Section 3.4 Firm-level Data				
Biscourp-Kramarz 07	Manufacturing Firms' Imports; Broad & Narrow Offshoring	Narrow (broad - narrow) has median 0.02 (0.02)	France to World	Employment falls by 0.13%, for average French firm (Table 8, column "All Origins")
Mion-Zhu 13	Same as Biscourp-Kramarz 07.	N.A.	Belgium to World	N.A.
Amiti-Davis 11	weighted average of industry tariff rates, weights = input shares from I/O table	Output (input) tariff has mean 0.17 (0.11)	Indonesia to World	Ave. wage of exporting (offshoring) firms rises by 0.82% (0.57%), or 0.0082 (0.0057) log points, relative to domestic firms, in Indonesia.

Table 2 Offshoring and Wages: Findings (Sections 3.3 through Section 4), Continued

Paper	Measure of Offshoring	Sample Mean/Median/Range	Where to Where	If Offshoring Rises by 10% (see p27 or Table Footnote)
Section 3.5.1 Publically Available Worker Data				
Liu-Trefler 08	Imports of Other Private Services from China & India, between Unaffiliated Parties	N.A.	U.S. to China and India	probability of switching industries (occupations) rises by 0.25% (0.13%), or 0.0025 (0.0013) log points, for average U.S. worker (Table 3, columns 1 and 2).
Ebenstein-Harrison-McMillan-Phillips 14	Employments of Foreign Affiliates of U.S. Multi-nationals	occupation-exposure sample has mean of 7,629 (13,268) workers for low (high) -income countries.	U.S. to World	Using cross-occupation variation, wage falls by 0.40% (rises by 0.34%), or 0.0040 (0.0034) log points, for the average U.S. worker (Table 2, 5th column)
Liu-Trefler 11	Imports of Other Private Services from China & India, between Unaffiliated Parties	N.A.	U.S. to China and India	probability of switching to lower-waged occupations rises by 0.39%, or 0.0039 log points, for average U.S. worker (Table 5, column 1).

Table 2 Offshoring and Wages: Findings (Sections 3.3 through Section 4), Continued

Paper	Measure of Offshoring	Sample Mean/Median/Range	Where to Where	If Offshoring Rises by 10% (see p27 or Table Footnote)
Section 3.5.2 Matched Employee-Employer Data				
Hummels-Jørgensen-Munch-Xiang 14	Manufacturing Firms' Imports; Broad and Narrow Offshoring	Mean is 8.89 (20.79) million DKK for narrow (broad) offshoring	Denmark to World	wage falls by 0.22% (rises by 0.29%), or 0.0022 (0.0029) log points, for the average Danish worker without (with) college education (Table 5, column 3)
Martins-Opromolla 09	Manufacturing Firms' Imports. Broad Offshoring only .	Mean is 0.19 - 0.24	Portugal to world	Coefficient estimates are not statistically significant with job-spell fixed effects (Tables 14 and 19)

Table 2 Offshoring and Wages: Findings (Sections 3.3 through Section 4), Continued

Paper	Measure of Offshoring	Sample Mean/Median/Range	Where to Where	If Offshoring Rises by 10% (see p27 or Table Footnote)
Section 4 Variation of the Effects of Offshoring Across Occupations				
Criscuolo-Garicano 10	Firms' Imports of Services	N.A.	U.K. to World	N.A.
Ottaviano-Peri-Wright 13	Average Tariff Rates; employment of foreign affiliates of U.S. Multi-nationals	N.A.	U.S. to World	N.A.
Crino 10	Same as Amiti-Wei 05	N.A.	U.S. to World	hard to summarize (results are employment elasticities by occupation)
Becker-Ekholm-Muendler 13	Employments of Foreign Affiliates of German Multi-nationals	N.A.	Germany to World	N.A.

Notes: For how we calculate “10% increase in offshoring” see p27 in the text. To be specific, its value equals 0.0035 for Feenstra and Hanson 1997, 0.0036 (narrow) and 0.008 (broad) for Feenstra and Hanson 1999, 0.1 log point for Hsieh and Woo 2005, Liu and Trefler (2008, 2011), EHMP (2014) and HJMX (2014), 0.000235 (service) for Amiti and Wei (2005, 2009), 0.002 (narrow) and 0.004 (broad) for Biscourp and Kramarz 2007, and 0.017 (output tariff) and 0.011 (input tariff) for Amiti and Davis (2011).