

# UC San Diego

## Recent Work

### Title

A Rationale For Evidence On Service Offshoring

### Permalink

<https://escholarship.org/uc/item/5s4056z6>

### Author

Tobal, Martin

### Publication Date

2011-09-01

# A Rationale For Evidence On Service Offshoring\*

Martin Tobal

UCSD

## Abstract

On the one hand, empiricists debate on which and how many labor dimensions are relevant for understanding the employment effects of the 1990's service offshoring boom. On the other hand, theorists pursue trade theory's traditional goal: to explain wage-responses to the shock. This paper rationalizes recent evidence on employment and reconciles theory with a current empirical debate. To this purpose, the article derives employment responses that are continuous in occupations' offshoring costs and depend on two labor dimensions: skill-intensities and tradeability characteristics. Furthermore, the paper yields intuitive wage-responses and addresses theorists' traditional concern. In particular, under the assumption that knowledge is occupation-specific, the article derives wage-responses that are not fully explained by skill-levels. More precisely, service offshoring deteriorates the wage of "many" skilled workers whose tasks have relatively low offshoring costs.

---

\*COPYRIGHTED BY MARTIN TOBAL, all rights reserved. PLEASE DO NOT CITE OR CIRCULATE WITHOUT PRIOR PERMISSION OF THE AUTHOR, THIS IS AN INCOMPLETE DRAFT. E-mail correspondence: mtobal@ucsd.edu I am grateful for funding from Fundacion ICO and deeply thankful to my advisor Prof. James E. Rauch. I am also grateful to Prof. Gordon Hanson, Thomas Baranga, Marc Muendler and other attendants to UCSD seminars for valuable comments.

# 1 Introduction and Motivation

The Information and Communication Technologies (ICT) revolution extended the traditional notion of offshoring to the purchase of foreign services. Before the revolution, offshoring only referred to relocation of production stages abroad. However, the technological improvements allowed for previously nontradeable services to be delivered from remote distances at low costs, in the 1990's. Consequently, firms started to offshore services to low-wage countries.[16][25]

Furthermore, the new form of offshoring brought fears and political debates.[17] Detractors argued that service offshoring would create employment and income losses. In particular, they argued that the white collar population from developed countries would be the great losers from the service offshoring boom.[2] This paper sheds light on these concerns.

Globalization and international trade have created losers since the late 19th century.[5] In the skill-abundant countries, the "first unbundling" in Badwin's words, contracted output in the sectors that most intensively used unskilled labor. These output contractions reduced the demand for unskilled workers and deteriorated their employment conditions. Furthermore, the boom in relocation of production stages harmed unskilled workers in the 1980's, as well. These workers had to face competition from their foreign pairs because the relocated stages were unskilled labor intensive.[15] Hence, losers from trade have traditionally been recognized by their skill group.

As the ICT revolution inaugurated a new globalization era, [8][18] the classification into skill groups might have lost its ability to distinguish losers from trade. The ICT revolution might have caused heterogeneous offshoring costs reductions for occupations with similar skill intensities. Therefore, workers with the same skill levels might feel differently the effects of the service offshoring boom.

As highlighted by many authors,[5] the commencement of a new era might require a new paradigm. Empiricists and theorists have partially responded to this need. Empiricists are replacing the sector and firm levels of disaggregation with the occupational level. This finer disaggregation permits them to capture within skill-group heterogeneity and, ultimately, to compare employment responses across occupations. Different responses within skill groups would confirm the need for a new labor classification.

Along these lines, several authors have proposed a classification accounting for differences in the offshoring costs of labor tasks. According to this view, employment should only respond negatively in occupations whose offshoring costs fell.[5] Therefore, employment should fall among call center agents, whose tasks are easily offshored, but not among truck drivers, whose tasks are not offshorable.

Even more recently, some evidence (Autor *et al.* (2008)[4]; Becker *et al.* (2009)[6]; Crino (2009)[11] and Crino (2010)[12]) suggests that the traditional skill-approach should be combined with differences in tradeability characteristics. In particular, Crino shows that the two labor dimensions jointly determine the employment responses of the U.S. white collar population. There is not a conclusive answer yet on

which and how many of the labor dimensions are relevant for understanding offshoring effects. This is still a controversial academic debate.

Theorists have responded to the hypothetical needs created by the ICT revolution, as well. However, these responses ignore the concerns risen by empirical work. Whereas empirics mainly turned its attention to employment responses, theory has followed its traditional goal: to explain the skill premium behavior. Furthermore, some models classify labor in two dimensions, but they give a low weight to tradeability. In particular, this weight is insufficient to address the empirical question on asymmetries across occupations. Hence, theory and empirics are growing apart.

The greatest contribution of this paper is to connect the empirical and theoretical work on service offshoring. Three characteristics of this article reconcile theory with recent empirical debates.

First, the model is a joint explanation: it explains wage and employment responses to service offshoring. Wage-responses are derived from the assumption of labor immobility in the short-run: as the ICT revolution hits the economy, occupational wages move to restore equilibrium in the labor markets. These wage-changes give workers incentives to switch to better-paid occupations. Employment responses then result from the switching among occupations.

Second, the model does not provide a unicasual explanation. As opposed to existing literature, a unique labor dimension does not fully explain responses to service offshoring. Instead, both dimensions play a significant role: tradeability and skill characteristics jointly determine employment and wage-responses to service offshoring. This property of the model approaches theory to the empirical debate mentioned above.

Third, the model can be confronted with data. In particular, wage and employment responses are continuous with respect to the offshoring costs of the occupations. Continuity represents a contribution to the existing literature, in which labor with similar tradeability responds very differently to the technological shock. Besides, continuity approaches theory to recent empirical literature, which builds continuous indices to measure tradeability.

Furthermore, since wage-responses are not fully explained by skill levels, this model proposes more intuitive explanations than existing models. In my framework, service offshoring causes wage-loses for occupations with low-offshoring costs and wage-increases for occupations with high offshoring costs. In other words, the ICT revolution reduces radiologists' wages, but it makes physicians better off. Besides being intuitive, this result is supported by empirical evidence for white-collar occupations.

Moreover, this paper makes a purely theoretical contribution. When determining the set of offshored activities or services, existing offshoring models emphasize either tradeability or skill intensities. This paper provides a unified framework, in which all aspects of the activities play a significant role.

In a stream of models, production activities are either tradeable or non-tradeable. Therefore, the set of offshored activities is exogenous, as for the tradeability dimension of labor. These models emphasize

the skill dimension and make a factor proportion argument: developed countries relocate activities or services that are unskilled labor intensive.<sup>1</sup>

Another stream lets offshoring costs differ within skill groups. In these models, the set of offshored activities is endogenous and determined by skill and tradeability characteristics. However, these setups assume a one-to-one mappings between offshoring costs and factor intensities. Hence, the role of tradeability becomes as little as in the previous stream.<sup>2</sup>

In a third stream, the sets of offshored tasks or inputs are endogenously determined, as well.<sup>3</sup> Furthermore, the mapping between factor intensities and offshoring costs is not one-to-one, then tradeability plays a significant role in determining offshored activities. In other words, inputs with a given factor intensity may or may not be offshored, depending on their offshoring costs. These models shed light on the role of tradeability.

My framework integrates the factor proportion argument and tradability analysis. To this purpose, it considers two skill groups and two sectors: one sector produces the skill intensive good and the other produces the unskilled labor intensive product. The production of each good is given by a continuum of tasks, which I interpret as occupations.<sup>4</sup>

I let these tasks differ in their factor intensities. Moreover, I link the intensities to sectors: skilled tasks are specific to the production of the skill intensive good. Linking factor intensities to sectors permits to make a straightforward factor proportion argument: skill-abundant countries offshore a larger set of unskilled tasks. This property makes the model different from the third and similar to the first two streams mentioned above.

Furthermore, I let the tasks differ in their tradeability characteristics. The model breaks the one-to-one mapping between factor intensities and offshoring costs. Therefore, tradeability becomes relevant for determining the set of offshored services. This property makes the model different from the first two streams. Moreover, this property reconciles the three streams.

Finally, consider the occupation switching mentioned above. In my model, the ICT revolution creates incentives for workers to switch to non-offshored occupations. To this purpose, workers acquire specific human capital through a retraining process. This notion of retraining differs from the traditional concept and has different public policy implications.

On the one hand, traditional frameworks study the acquisition of higher skills, which workers use for switching to skill intensive sectors.<sup>5</sup>The natural interpretation for this retraining notion then is the acquisition of a college degree. Furthermore, this retraining concept suggests that authorities facilitate skill-upgrading and provide more analytic skills to the developed countries' population. As an example,

---

<sup>1</sup>See Bhagwati et al. 2004[7], Deardorff 2005[14], Treffler, 2006 [33] and Markusen, 2006[27] for some examples.

<sup>2</sup>Kohler, 2004[23]and Basco, 2010[13] for some examples.

<sup>3</sup>Lommerud et al. 2009[26] and Grossman and Rossi-Hansberg, 2008[19].

<sup>4</sup>In the following, except in Section 2. I use the terms tasks and occupations indistinguishably.

<sup>5</sup>See Neary (1985)[29] for an example.

policy makers should induce students to become computer programmers instead of cashiers.

On the other hand, my retraining model highlights the relocation of workers across occupations with different tradeability characteristics. In order to fulfill less tradeable occupations, workers might not have to acquire a college degree, but only to spend some time at a community college. Moreover, my retraining notion suggests that authorities induce students to become labor relations managers, whose work requires interpersonal contact, rather than web designers, whose work can be delivered from remote distances.

The consideration of a non-standard retraining notion responds to the distinctive characteristic of the 1990's offshoring boom. The standard retraining notion seemed more suitable for periods in which competition occurred within sectors. However, the ICT revolution triggered international competition among individual workers employed in the same occupations. Hence, labor relocation seemed more natural among occupations than among sectors.

To summarize, the main goal of this article is to connect theory to recent empirical debates. Furthermore, the paper addresses the labor relocation caused by the revolution and questions the role of public policy in the context of an ICT-world. In the attempt of achieving these goals, the article unifies streams of offshoring theory.

I develop the model in the remainder of the paper. In section 2. I present recent empirical findings on offshoring and I present evidence that supports my theoretical approach. In section 3. I display the setup and solve the model allowing for trade in goods. In section 4. I allow for service offshoring and obtain wage-responses at the occupational level. I feed a simple retraining model with these wage-responses in Section 5. Section 6. summarizes the results and Section 7. gives a first step in understanding the new role of public policy. Section 7. concludes.

## 2 Stylized Facts and Theoretical Literature

This section presents empirical evidence on the economic consequences of service offshoring. First, I present the time-trend of service offshoring and use this trend to justify aspects of my theoretical approach. Second, I go over evidence on employment and wages and show how existing theory fails to explain the most recent findings. Finally, I provide empirical evidence supporting my assumption on labor immobility in the short run.

Before the ICT revolution, service offshoring was almost inexistent. However, the technological improvements caused an abrupt and discreet change in its time-trend: service offshoring has been sharply rising since then. Amiti and Wei (2005,2009)[2][3] Crino (2009)[11] and Treffler (2006)[34] have documented the existence of two easily distinguishable periods for different countries.

Inspired by Feenstra and Hanson's work on material offshoring, Amity and Wei retrieved IMF trade data and obtained proxies for service offshoring at the industry level. The authors then used these proxies to compute U.S and U.K. average shares of service imports. Their data shows that the U.S. average share increased from 0.4 percent to 0.8 percent over the 1992-2005 period. Similarly, the U.K. average share rose from 3.5 to 5.5.

Crino built the same proxies as Amity and Wei using BEA data for U.S. manufacturing industries. His analysis suggests that service offshoring was almost zero before 1995 and started to rise exponentially since then. Finally, Treffler provided evidence for the case of Canada. The author retrieved data from the OECD for 1997-2004 and studied growth rates for different services categories. He concluded that service offshoring started to grow exceptionally in the late 1990's.

These particularities of the service offshoring time-trend shape the choice of my theoretical approach. In particular, I model the ICT revolution as a discreet and abrupt reduction in offshoring costs. This reduction divides my analysis in two regimes. The first regime, characterized by high offshoring costs, represents the previous revolution period; the second regime represents the post-revolution period, in which offshoring costs are relatively low. The comparison of these two periods allows me to isolate the economic effects of the service offshoring boom.

The two-regime approach differs from the traditional comparative-statics analysis, which focuses on marginal changes and requires for service offshoring to have been taking place already. This article is not the only to use the two-regime approach; Bhagwati *et al.* (2004)[7], Deardorff (2005)[14] and Markusen (2006)[27] use the same methodology.

Let me now comment on the evidence about employment responses to offshoring. Two related questions have dominated the scene of empirical work. Addressing a major concern in the media,[17] empiricists have attempted to measure the number of jobs that are or will be potentially lost to service offshoring. A different but closely related question is on the nature of these jobs. The two questions are related because, as several authors argue, the nature of a job might be relevant for its propensity to be offshored.

Amiti and Wei (2005,2009)[2][3] studied the magnitude of the aggregate offshoring effect at the sector level. The authors took first differences in their labor demand specifications and estimated the relationship between job growth and growth of offshoring. For the U.S. the effect was significant, negative and small. Even more interestingly, this result was sensitive to the aggregation level. The small and significant effect was for a sample decomposed in 450 sectors. However, as their sample was decomposed into 96 sectors, the significance disappeared. Amiti and Wei speculated that the sensitivity was explained by asymmetric employment responses across sectors.

Other authors argue that the nature of an occupation is relevant for its propensity to be offshored, so they work at finer disaggregation levels. These studies have attempted to distinguish occupations affected

by offshoring from a judgment on their offshorability characteristics. Several characteristics have been proposed.

Blinder (2009)[9] distinguished services according to whether they required face-to-face interaction.[8] Services not requiring face-to-face interaction were called impersonal services and considered easier to offshore. Using this criterium, the author found that between 22% and 29% of all U.S. jobs are or will be potentially offshorability in the coming two decades. Furthermore, Blinder found no correlation between an occupation's offshorability and its skill intensity. The non-correlation emphasized tradeability, as it separated its role from the effect of skill intensities, the traditionally considered labor dimension. Hence, Blinder's work highlights the importance of tradeability.

Van Welsum and Vickery (2005)[35] combined Blinder's idea with additional features of occupations. The authors classified occupations not requiring face-to-face interaction, being involved in routines tasks and having become tradeable with the ICT revolution as offshorable occupations. According to their data, around 20% of total employment in the EU15, the United States, Canada and Australia could potentially be affected by offshoring.

Jensen and Kletzer determined occupations' offshorability using geogographic concentration. First, the authors distinguished occupations involved in the production of services that were geographically concentrated in the U.S. These occupations were classified as tradeable in the U.S. and therefore, as tradable internationally. As Blinder, the authors investigated a potential correlation between offshorability and skill intensities: they found that workers in tradable occupations were more highly educated.

Moreover, Jensen and Kletzer studied employment growth rates across tradeable and non tradeable occupations with different skill intensities. Their data showed higher rates for tradeable service occupations. As this outcome is linked to the correlation between tradeability and skill intensities, their results suggest that employment growth rates were higher for skill intensive occupations. Therefore, their results are consistent with a comparative advantage argument.<sup>6</sup> Jensen and Kletzer's work emphasize the factor proportion argument and skill dimension of labor.

The apparent disparities between Blinder and Jensen and Kletzer's results on the mentioned correlation and employment effects raise the question on which dimensions of labor are empirically relevant. Whereas Blinder and other authors emphasized tradeability characteristics, Jensen and Kletzer considered these characteristics, but concluded that skill levels were more relevant. These two approaches were reconciled by Crino for the case of the white-collar population.

Crino investigated the role of skills and tradability characteristics jointly for the U.S. white-collar population. His sample covered 112 U.S. occupations and 144 industries between 1997 and 2006. In order to measure tradeability, the author constructed occupation indices defined over a continuous space

---

<sup>6</sup>Interpreting causality should be done with cautious here because provide summary statistics but the do not run an econometrics analysis.



and based on the job's characteristics considered by Van Welsum and Vickery.

The author derived labor demands for occupations in which service offshoring acted as a shifter. Then, he estimated demand elasticities with respect to that shifter. Two major findings summarize his results. First, there was a higher number of positive (negative) elasticities among the skilled (unskilled) occupations. In addition, the occupations with negative elasticities tended to be more tradable.

Second, Crino run a joint analysis, in which the author mixed tradeability features and skill intensities. This analysis disentangled the role of each labor dimension. In particular, the probability that employment responds positively was increasing in an occupation's offshoring costs, given its skill intensity. Furthermore, this probability increased with skill intensities, given tradeability characteristics. To summarize, Crino's results suggest that the two labor dimensions should be considered, and that they should be considered jointly.

Note that Crino's work is compatible with Amity and Wei's. As speculated by the latter, Crino's results show that data should be disaggregated at a higher level. If each sector had a different mix of occupations, which is highly probable, Crino's results would explain why sector-responses were asymmetric in Amity and Wei's sample.

Furthermore, Crino's work is consistent with Jensen and Kletzer's, as well. In their paper, the employment growth rate is negative for tradable occupations in the lowest-skill quartile, but positive for the rest of quartiles. This indicates that the impact of service offshoring on employment depends on the two labor dimensions, which is the main message of Crino's results.

In addition, Crino's work is consistent with other studies arguing that the two labor dimension are relevant for explaining labor outcomes in the 1990's and 2000's. Author et al. (2008)[4] suggested that shifts in the demands for non-routine (less tradeable) tasks could partially explain the polarization in U.S. earnings. According to the authors, this explanation should be combined with shifts in the standard skill demand because employment and wage growth were positively correlated by skill percentile.

Crino's results are rationalized by the model I propose in this paper. To the best of my knowledge, no existing model rationalizes this evidence. A good approach in this direction was taken by Markusen and Strand (2008)[28]. The authors attempted to introduce a role for tradeability in a standard factor proportion model. Entrepreneurs were the least tradeable occupation, but firms could only offshore their jobs by setting headquarters in the foreign country. Their approach is different from mine as I propose a continuous measure of tradeability and let occupations continuously respond according to this measure. Furthermore, I do not constraint myself to FDI decisions.

Another big step was that given by Grossman and Rossi-Hansberg. In their setup, the employment implications of service offshoring are different across skill-groups, for some cases. In particular, if offshoring costs differ across skill-groups, the extensive margins of the affected tasks differ across skills. If offshoring costs differ across industries, the intensive margin at which the tasks are affected depends on their skill

intensities. Furthermore, their model produces different employment implications for the set offshored and non-offshored tasks.

As for employment outcomes, my approach differs from theirs in two three ways. First, my model generates asymmetric intensive and extensive margins across skill-groups. Second, in order to create these asymmetries, my setup relies on a factor proportion argument and not on correlations between tradeability and skill-groups or sectors. Third, my setup generates different employment implications within the set of offshored tasks, according to these tasks' offshoring costs.

Let me now turn to the evidence on wages, which is little. Crino (2010)[12] found positive and significant correlation between changes in occupational wages and changes in occupational employment, even after controlling for variations in the occupational supply. In other words, wages have increased in skilled occupations composed by hardly tradable tasks. This indicates that changes in employment are more likely to have been produced by demand shocks.

None of the existing models rationalizes this evidence as, in these models, wage responses are fully explained by skill-levels. In order to introduce a role for tradeability characteristics, I rely on the "putty-clay" assumption: as human capital is task-specific, once that labor putty is allocated to tasks, it hardens into occupation clay. Therefore, labor cannot shift after a shock and wages must absorb all the adjustment in the short-run.

This model explain Crino's empirical evidence on wages. To this purpose, I follow existing offshoring theory and distinguish two effects on wages. First, I consider a *productivity effect*. Existing theory recognizes channels through which offshoring increases the demand for domestic workers. In most cases, labor demands rise due to the increase in domestic firms' productivity generated by offshoring.<sup>7</sup>My productivity effect differs from the literature's in that offshoring benefits every worker, in this model. This difference has a non-trivial implication: service offshoring makes some workers better off, even when their jobs are offshored. A second channel developed by the literature shows that domestic workers are more exposed to foreign competition due to offshoring. This higher exposure to foreign competition tends to push domestic wages down. As opposed to the literature's, my model's competition effect does not act homogeneously across workers with different offshoring costs. Foreign competition more strongly harms workers in more easily tradeable occupations.

Finally, let me introduce some empirical evidence on my "putty-clay" assumption, which drives my model's wage results. Kambourov and Manovskii (2009)[21], who studied the U.S. economy for 1969-1997, claimed that wage changes were linked to labor mobility over that period. In particular, the authors' suggested that much of the increase in wage inequality was explained by two features: changes in the demands for specific occupations and the occupational specificity of human capital.

Furthermore, in a different paper (Kambourov and Manovskii (2009)[22]), the authors found empirical

---

<sup>7</sup>See[26]and[19]for some examples.

support for the specificity of human capital. Ritter (2008)[31] built upon Kambourov and Manovskii's work and found that human capital tended to be more specific in occupations that were potentially tradable. The author designed a model to explain workers' reallocation across occupations. However, Ritter focused on the dynamics of adjustment and proposed a calibrable model, for which he did not derive theoretical results. Moreover, the author did not endogenize firms' offshoring decisions.

### 3 Good-Trade Equilibrium

In this section, I present a Two-Good Two-Factor model. I use this model to study a regime in which offshoring costs are so high that firms do not import tasks.

There are two world regions: Home and the rest of the world. Variables that refer to the rest of the world are identified by a superscript asterisk (\*). Skilled and unskilled workers are distributed over continuums whose lengths are  $L_s$  and  $L_u$ , respectively. Home is a relatively skill-abundant country, which is formally stated as follows:

$$(1) \frac{L_s}{L_u} > \frac{L_s^*}{L_u^*}$$

The two final goods are a skill-intensive product denoted by  $Y_s$  and an unskill-intensive good denoted by  $Y_u$ . I focus on the case in which Home exports the skill-intensive good. This is the most empirically appealing case and prediction of a Two-Good Two-Factor model from any textbook.

Home is a small country with technological advantage. As a small country, Home does not affect either good prices or foreign wages, which are taken as exogenous. Therefore, domestic wages should be expressed in terms of them in equilibrium. Appendix 1. shows that if Home were a large country, domestic wages could be written in terms of factor endowments, technologies and the measure of transportation cost I introduce below.

Production is modelled in terms of tasks, so that the model's disaggregation level is appropriate for matching the data. As noted in the introduction, I interpret these tasks as occupations and refer indistinguishably to both terms. Technologies are given by the Cobb-Douglas functions used by Acemoglu *et al.* which I display below.[1]

There are two types of tasks, skilled and unskilled tasks. I follow Grossman and Rossi-Hansberg and assume that tasks performed by a given factor require similar amounts of that factor. Without loss of generality, skilled tasks require a unit of skilled labor and unskilled tasks a unit of unskilled labor.

Furthermore, tasks are specific factors: skilled tasks are only used for producing  $Y_s$  and unskilled tasks only used for producing  $Y_u$ . Also without loss of generality, the measure of tasks for each factor is normalized to 1. Hence, technologies are summarized by the following expressions:

$$(2) Y_s = A e^{\int_0^1 \ln(z_{i,s}) d_i} \quad (3) Y_u = A e^{\int_0^1 \ln(z_{i,u}) d_i}$$

$$(4) Y_s^* = e^{\int_0^1 \ln(z_{i,s}^*) d_i} \quad (5) Y_u^* = e^{\int_0^1 \ln(z_{i,u}^*) d_i}$$

where  $i$  is an index of tasks,  $z_{i,j}$  denotes the amount of task  $i \in [0, 1]$  used in the production of good  $j \in [s, u]$  and  $A > 1$  denotes Home's Hicks-neutral technological parameter. Notice in equations (2) – (5), two features of the production functions. First, the symmetry across the  $j$ -skilled tasks in the expressions displayed above. The implication of this symmetry is that output is maximized as tasks are used in the same quantity, for a given total amount of labor type  $j$ . Second, outputs are positive only if every single task is used.

The goods market is perfectly competitive and trade costs, which are of the Samuelson-Bergson iceberg type (1952)[32], apply to both industries. In particular, for one unit of a product to arrive in the other region,  $\tau$  ( $\tau > 1$ ) must be shipped.

We are now ready to approach the equilibrium of this economy. An equilibrium is characterized by a sequence of wages  $\{w_{i,j}\}_{i \in [0,1]}^{j \in [s,u]}$  that fulfills two sets of requirements: the task-market clearing and zero-profit conditions. Let me start with market clearing and, more specifically, with the output constrained demands for tasks. Firms minimize costs given the technology displayed in equations (2) – (4) and derive the following demands:

$$(6) z_{i,j}^d = \left( \frac{e^{\int_0^1 \ln(w_{i,j}) d_i}}{A w_{i,j}} \right) Y_j \quad \forall j \in [s, u]; \forall i \in [0, 1]$$

$$(7) z_{i,j}^{*d} = \left( \frac{e^{\int_0^1 \ln(w_{i,j}^*) d_i}}{w_{i,j}^*} \right) Y_j^* \quad \forall j \in [s, u]; \forall i \in [0, 1]$$

where  $z_{i,j}^d$  is the output constrained demand for task  $i$  in sector  $j$ , and  $w_{i,j}$  is the price of that task. Notice that in each region, the  $j$ -skilled demands are symmetric across tasks, which is an implication of the symmetry in the production function mentioned above.

The symmetry in the demands gives no demand-driven reasons for prices to be different in equilibrium: only if the supplies of tasks were different, their prices could differ in equilibrium. Notice also that the only case for which the output constrained demand for task  $i$  in sector  $j$  goes to zero is when its price  $w_{i,j}$  goes to infinite. This property guarantees that every single task is used in equilibrium.

I next comment on the other side of the market, the supply of tasks. A worker is able to supply any of the tasks intensive in her skill level. Among these tasks then, every worker prefers to supply the task(s) with the highest return(s). Therefore, as long as a task(s) does not have the highest return, no worker wants to supply it. More formally, denote  $i'_j$  the  $j$ -skilled task(s) with the strictly highest return(s), then the supply of any task  $i_j \in [0, 1]$   $i_j \neq i'_j$  is equal to zero.

Let me use the task demands and supplies to describe the wage sequences  $\{w_{i,j}\}_{i \in [0,1]}^{j \in [s,u]}$  that clear the task-markets. The task-markets clearing sequences are such that all prices of the  $j$ -intensive tasks are equal. In other words, any sequence for which there is a  $j$ -skilled task(s)  $i'_j$  with a strictly higher return(s) is not an equilibrium, as shown in Appendix 2. More formally, if a sequence of wages  $\{w_{i,j}\}_{i \in [0,1]}^{j \in [s,u]}$  clears the task-markets, this sequence is characterized by the following equations:

$$(8) w_{i,s} = w_s \quad \forall i \in [0, 1] \quad w_{i,u} = w_u \quad \forall i \in [0, 1]$$

$$(9) w_{i,s}^* = w_s^* \quad \forall i \in [0, 1] \quad w_{i,u}^* = w_u^* \quad \forall i \in [0, 1]$$

Equations (8) and (9) provide price-conditions under which task-markets clear. Plugging these price-conditions in the tasks demands displayed in (6) and (7), I obtain the equilibrium quantity of each task. These quantities determine the allocation of labor across tasks, which I display in the following:

$$(10) z_{i,s} = L_s \quad \forall i \in [0, 1] \quad z_{i,u} = L_u \quad \forall i \in [0, 1]$$

$$(11) z_{i,s}^* = L_s^* \quad \forall i \in (0, 1) \quad z_{i,u}^* = L_u^* \quad \forall i \in [0, 1]$$

Equations (10) and (11) state that skilled and unskilled labor are evenly allocated across tasks in equilibrium. If no ICT revolution took place and the world were perpetually well described by this first regime, the allocations displayed in (10) and (11) would be the Pareto efficient allocations. The reason being that these are the allocations that maximize output, as noted in the discussion of the production function. In particular, when labor is evenly allocated across tasks, output in each industry is given by the following expressions:

$$(12) Y_s^1 = AL_s \quad (13) Y_u^1 = AL_u$$

$$(14) Y_s^{1*} = L_s^* \quad (15) Y_u^{1*} = L_u^*$$

where  $Y_j^1$  is the equilibrium output of good  $j$  in the first regime. Note in equations (12) – (15), the production of each good is determined by countries' technologies and labor endowments of the specific factor. Furthermore, the two world-regions produce both goods; in this model, equilibrium requires incomplete specialization.

Equations (8) – (15) define market clearing in the task-markets. In order to solve for domestic wages in equilibrium, I use this task-market clearing and the zero-profits conditions, which I approach below. Notice first that equilibrium requires incomplete specialization. Under incomplete specialization, the zero-profit conditions are fulfilled when the effective price of each good equals its unit cost of production. Moreover, since the production functions displayed above summarize CRS technologies, units cost of production equal marginal costs. These marginal costs are given by the following:

$$(15) MC_j = \frac{e^{\int_0^1 \ln(w_{i,j}) d_i}}{A} \quad \forall j \in [s, u]; \quad \forall i \in [0, 1]$$

$$(16) MC_j^* = e^{\int_0^1 \ln(w_{i,j}^*) d_i} \quad \forall j \in [s, u]; \quad \forall i \in [0, 1]$$

where  $MC_j$  denotes the unit cost of production in sector  $j$ . The expressions displayed in (15) and (16) are readily simplified by imposing market clearing in the task-market. In particular, I impose the price conditions displayed in equations (8) and (9) in the marginal cost definitions shown above. The unit costs of production are then given by the following expressions:

$$(15') MC_j = \frac{w_j}{A} \quad \forall j \in [s, u]; \quad \forall i \in [0, 1]$$

$$(16') MC_j^* = w_j^* \quad \forall j \in [s, u]; \quad \forall i \in [0, 1]$$

The last step in setting the zero-profit conditions is to equalize the unit costs displayed above to the effective price of the goods in each world region. Notice that effective prices are different across regions because transport costs prevent price equalization. The zero-profit conditions are given by the following expressions:

$$(17) p^T = \frac{w_s}{A} \quad (18) \tau = \frac{w_u}{A}$$

$$(19) p^T \tau = w_s^* \quad (20) 1 = w_u^*$$

where  $p^T$  denotes the equilibrium relative price of the skill-intensive good,  $\tau$  is the iceberg cost measure and the number 1 denotes that the price of the unskill intensive good has been chosen as the numeraire. Equations (17) – (20) state that if Home imports the unskill-intensive good, its domestic price equals its world price times the iceberg costs measure.

Let me now rearrange equations (17)–(20) in order to display relative wages by skill-groups. I will use these relative wages to provide intuition on the ICT revolution effects in the next Section. Rearranging equations (17) – (20) yields:

$$(21) \frac{w_s}{w_s^*} = \frac{A}{\tau} \quad (22) \frac{w_u}{w_u^*} = A\tau$$

Note in equations (21) – (22), both skilled and unskilled domestic relative wages increase with Home’s technological advantage. In other word, Home’s technological advantage is the reason for relatively high wages. Furthermore, if this advantage is sufficiently large, firms will find it profitable to offshore labor in the next section. Notice also that the impact of transportation costs is not the same on skilled and unskilled relative wages. Moreover, its impact is not the same across regions either. This statement is more formally written as follows:

$$(23) \frac{w_s}{w_u} = \frac{1}{\tau^2} \left( \frac{w_s^*}{w_u^*} \right) < \frac{w_s^*}{w_u^*}$$

Equation (23) shows that the domestic relative wage is lower for skilled workers. In other words, transport costs do not allow for trade in goods to equalize relative wages: these relative wages still reflect differences in factor proportions and Home’s comparative advantage in the skill-intensive good. The lack of relative factor prices equalization is the driving force generating most of the results in this model. In particular, it guarantees that offshoring has heterogeneous effects on skilled and unskilled workers.

The relationship between non factor price equalization and asymmetric offshoring effects has been emphasized by other factor proportion models. For example, in Deardorff’s one-product model (2005)[14], set at a lower disaggregation level, relative factor prices do not equalize because firms offshore a production activity, instead of occupations. In this paper, I choose a more disaggregated level and a simpler but realistic argument, such as transportation costs. I proceed this way as I prefer to emphasize implications: service offshoring harms more strongly unskilled than skilled workers.

## 4 Task and Good Trade Equilibrium

In this section, I present the second regime of the model, in which offshoring costs fall and become so low that firms decide to import tasks. Then, I solve for domestic wages in equilibrium and compare these wages to those found in the previous section. The comparison provides wage responses, which I use to feed my retraining model, in the next section.

In the previous section, firms' only choice was to decide how much of each task to purchase. In this section, firms decide besides on which tasks to offshore. I let offshoring costs differ across tasks, and determine a cutoff traded task, which I call  $I$ . As Grossman and Rossi-Hansberg, I order tasks in each continuum, so that offshoring costs are non-decreasing and a task's offshoring costs are indexed by  $i$ . These costs are expressed in terms of foreign labor requirements: a firm that performs task  $i$  abroad requires  $\beta t(i)$  units of foreign labor.

The parameter  $\beta$  denotes the Grossman and Rossi-Hansberg's shift parameter. I model the ICT revolution as a discreet fall in the value of this parameter, which reduces offshoring costs unevenly across tasks. Therefore, only some of the tasks will be offshored in equilibrium, under the assumptions I display below. In particular, a task  $i$  will be offshored if and only if its offshoring costs are lower than those of the cutoff traded task. In other words, task  $i$  will be offshored if and only if  $i < I$ .

In order to rule out the uninteresting case in which all tasks are imported, I assume that  $t(\cdot)$  is "increasing enough." This function is assumed to be twice continuously differentiable, which simplifies the exposition. In addition, I assume that  $\beta t(0) > 1$ , so that at least some offshoring takes place. Moreover, to ensure that at least some skilled tasks are offshored, I need an additional assumption. This condition guarantees that the first regime's relative wage for skilled workers is sufficiently large. In particular, I make the following assumption :

$$(24) \frac{A}{\tau} > \beta t(0)$$

Assumption (24) has a straightforward interpretation: Home's technological advantage must be sufficiently large. As Home has a great technological advantage, its skilled wage is so high that it becomes profitable for domestic firms to offshore skilled labor.

We are now ready to approach the second regime's equilibrium. As in the last section, an equilibrium sequence of wages  $\{w_{i,j}\}_{i \in [0,1]}^{j \in [s,u]}$  clears the task-markets and fulfills the zero-profit conditions. However, since firms must decide on which tasks to offshore, an equilibrium sequence must fulfill an extra condition in this section: firms' choice of the cutoff traded task  $I$  must minimize costs, given the tasks prices implied



by the sequence.

Let me first consider the cost minimizing condition. To this purpose, I distinguish a different cutoff for each skill-group. There is a cutoff for skilled labor  $I_s$ , which slices a continuum into offshored and non-offshored skilled tasks; besides, there is a cutoff for unskilled labor  $I_u$ , which slices the other continuum into offshored and non-offshored unskilled tasks. Consider two observations regarding these cutoffs.

First, the cutoffs differ in equilibrium. The reason is that offshoring unskilled labor is more profitable than offshoring skilled labor: the domestic unskilled relative wage is higher than it is the domestic skilled relative wage. Second, the cutoffs do not distinguish between Home-made and foreign-produced tasks. As noted in the introduction, human capital is occupation specific, so labor cannot be relocated across different tasks. Hence, all tasks are Home-produced in the short run.

When deciding which tasks to offshore, domestic firms' objective is to minimize their production costs. I next use the domestic marginal costs defined in equation (15) and show how these costs depend on the choice of the cutoffs. Firms' minimizing cost decisions are summarized by the following equations:

$$(25) \text{Min}_{J_s} MC_s(J_s) = \frac{e^{[1-J_s]\ln(w_{nt,s}) + \int_0^{J_s} \ln(w_s^* \beta t(i))}}{A}$$

$$(26) \text{Min}_{J_u} MC_u(J_u) = \frac{e^{[1-J_u]\ln(w_{nt,u}) + \int_0^{J_u} \ln(w_u^* \beta t(i))}}{A}$$

where  $J_j$  denotes a choice of the  $j$ 's skill-group cutoff,  $w_j^* \beta t(i)$  is  $i$  task's effective importing price, and  $w_{nt,j}$  is the price of any non-traded task. Notice in (25) and (26), all non-offshored tasks perceive the same wage -given a skill intensity-. Furthermore, the wage of each offshored task equals its importing effective price. As I show below, wages must fulfill these conditions so that task-markets are in equilibrium.

The minimization problems set in (25) and (26) yield straightforward offshoring rules. These rules are displayed in the following equations:

$$-import\ task\ i\ if\ and\ only\ if\ w_s^* \beta t(i) < w_{nt,s}$$

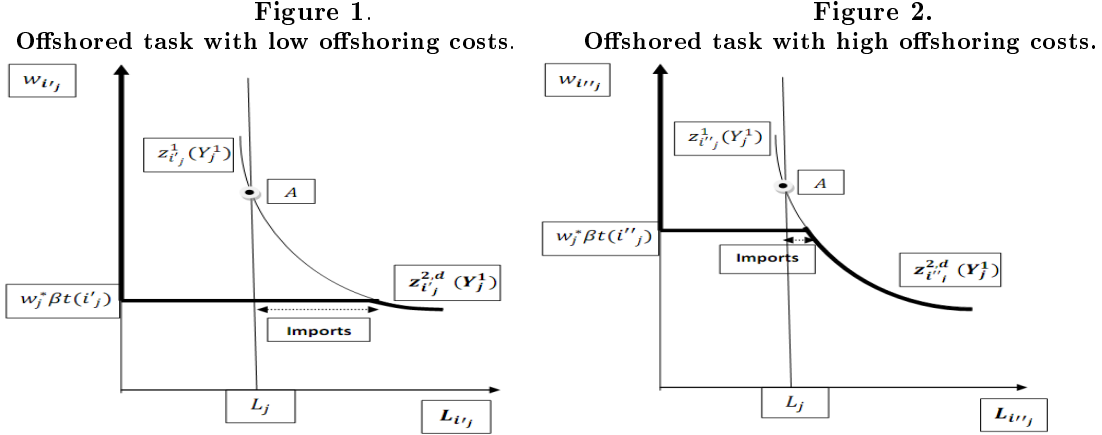
$$-import\ task\ i\ if\ and\ only\ if\ w_u^* \beta t(i) < w_{nt,u}$$

Domestic firms offshore a task  $i$  if and only if that reduces their marginal costs. This happens when the importing effective price of the task is lower than its price in the domestic market  $w_{nt,j}$ . From the offshoring rules displayed above, I obtain equilibrium conditions for the cutoffs:

$$(27) w_{nt,s} = w_s^* \beta t(I_s) \quad w_{nt,u} = w_u^* \beta t(I_u)$$

where  $I_s$  and  $I_u$  are the skilled and unskilled labor cutoffs in equilibrium. Equation (27) states that firms must be indifferent between offshoring and purchasing the equilibrium cutoff task in the domestic market. This equation establishes a relationship between non-offshored tasks prices and the cutoff traded tasks in equilibrium. The other relationship is given by the zero-profit conditions, which I approach at the end of this subsection.

Let me now turn to the second equilibrium condition: clearing in the domestic markets of tasks. Figure 1. displays the market equilibrium for a traded task  $i'_j$ . The heavy weighted curves represent the output constrained demand for this task, which I label  $Z_{i'_j}^{2,d}$ . The solid and lighter weighted curve represents its first regime's demand, which I label  $Z_{i'_j}^1$ , and Point A denotes the first regime's market equilibrium. Finally, the straight vertical line depicts the supply of the task. Notice in the two output constrained demands, I have imposed the equilibrium output of the first regime  $Y_j^1$ . However,  $Y_j^1$  needs not to be sector  $j$ 's production in this second regime.



In Figure 1.  $Z_{i'_j}^{2,d}$  behaves differently in each of the three easily distinguishable wage-zones. For wages greater than  $i'_j$ 's effective importing price  $-w_{i'_j} > w_j^* \beta t(i'_j) - Z_{i'_j}^{2,d}$  is a vertical line: as firms have access to task  $i'_j$  at a lower price, their demand of the domestic task is zero. For a wage equal to the task's effective importing price, firms are indifferent between offshoring and purchasing the Home-produced task. Therefore, they demand any quantity between 0 and the amount they would have demanded at the same price in the first regime. Finally, for wages lower than  $w_j^* \beta t(i'_j)$ , the demands are the same in the two regimes, as firms prefer not to offshore task  $i'_j$ .

As for the supply of the task, it is inelastic: workers supply the same amount as in the first regime. This is an implication of the putty-clay assumption: if workers wanted to fulfill a different task, they would have to invest time and money for additional specialized training. Workers might decide to

do so and supply high-priced tasks in the long run. However, they must supply their labor at whatever return they can in the short-run because retraining takes time.

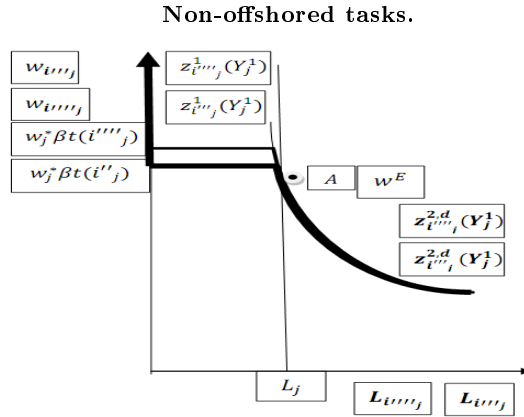
Figure 2. depicts equilibrium in the domestic market of a traded task  $i''_j$  with higher offshoring costs,  $i''_j > i'_j$ . The demand for this task is given by a similar reasoning to that described for task  $i'_j$ . However, notice in Figure 2. that as the effective importing price of  $i''_j$  is greater,  $Z_{i''_j}^{2,d}$  “breaks” at a higher wage.

In both Figures 1. and 2, equilibrium employment is determined by the supplies of tasks :  $L_j$  is the equilibrium quantity, as in the previous regime. Note that equilibrium wages are given by the tasks’ effective importing prices. This confirms that the assumptions I used in my analysis of the optimal offshoring rules were correct.

Furthermore, wages of tasks  $i'_j$  and  $i''_j$  are lower than their first regime’s price: Figures 1. and 2. show that if the output level were the first regime’s, the equilibrium of any imported task should lie South-East of Point A.<sup>8</sup>The intuition for this result goes as follows: service offshoring allows firms to purchase these workers’ tasks at lower prices. Therefore, their wages must fall, so that domestic markets clear in equilibrium. Let me call this effect of service offshoring on domestic wages the *foreign competition effect*, as it results from a higher exposure to foreign competition.

Moreover, notice that the equilibrium of a non-offshored tasks needs not to lie South-East of Point A, as this task is not imported. Figure 3 depicts equilibria for tasks  $i'''_j$  and  $i''''_j$ , where  $i'''_j > i''''_j > i''_j > i'_j$ . The strongly weighted curves denote the demand for task  $i'''_j$  and the mildly weighted curves denote the demand for task and  $i''''_j$ . Note that the two equilibria happen at Point A, associated to a wage equal to  $w^E$ . This wage is the same for the two tasks, which proves that the assumptions made in the analysis of the optimal offshoring rules were correct.

**Figure 3.**



Let me now approach the last equilibrium requirement: the zero-profit conditions. These conditions provide the second relationship between the prices of the non-offshored tasks and choice of the cutoffs.

<sup>8</sup>As I show below, this is not necessarily true as all offshoring effects are considered.

Therefore, these conditions, along with the optimal offshoring rules, determine the two endogenous variables in equilibrium.

In order to set the last equilibrium requirement, I use the definitions for marginal costs displayed in equations (25) and (26), the small-country assumption and the zero-profit conditions for the foreign region, displayed in equations (19) and (20).

As in the last section, firms make zero profits when unit production costs equal domestic prices. As for unit costs, I use equations (25) and (26). These equations assume that all non-offshored tasks perceive the same wage and that the wage of every offshored task equals its effective importing price. As shown above, these assumptions are implied by the task-markets clearing conditions, so equations (25) and (26) provide valid definitions for marginal costs. As for domestic prices, I use the the small-country assumption. Since Home is a small-country, it does not affect either good prices or foreign wages, and therefore, equations (19) and (20) are still valid in this second regime. Setting the zero-profit condition yields:

$$(30) \frac{w_s^*}{\tau} = \frac{e^{[1-J_s]\ln(w_{nt,s}) + \int_0^{J_s} \ln(w_s^* \beta t(i))}}{A}$$

$$(31) \tau w_u^* = \frac{e^{[1-J_u]\ln(w_{nt,u}) + \int_0^{J_u} \ln(w_u^* \beta t(i))}}{A}$$

Note that equations (30) and (31) implicitly define all vectors  $(J_j, w_{nt,j})$  that fulfill the zero-profit conditions. I next solve for non-offshored tasks prices, for which I manipulate the equations displayed above. The manipulation yields:

$$(30') w_{nt,s}(J_s) = e^{[\ln(w_s^*) + \frac{\ln(\frac{A}{\tau}) - I_s \ln(\beta) - \int_0^{J_s} \ln((i))}{1 - I_s}]}$$

$$(31') w_{nt,u}(J_u) = e^{[\ln(w_u^*) + \frac{\ln(A\tau) - I_u \ln(\beta) - \int_0^{J_u} \ln((i))}{1 - I_u}]}$$

Equation (30') states that the price for a non-offshored skilled tasks depends on Home's technological advantage, the transport cost measure, the G-R shift parameter, and the choice of the cutoff task  $J_s$ . Equation (31') is the analogous for the price of the unskilled tasks.

Notice in (30'), the price of the non-offshored tasks decreases with any parameter-change that reduces the unit production cost, holding the cutoff constant. Consider a fall in the unit production cost caused by a rise in Home's Hicks neutral parameter, without loss of generality. As Home becomes more productive, the price of the non-offshored tasks must rise, so that the marginal cost returns to its original value. As the marginal cost returns to its original value, the zero-profit condition is restored.

Finally, equation (30') provides a relationship between the price of the non-offshored tasks and cutoff choice  $J_s$ . In particular, this equation shows the price that fulfills the zero profit conditions when  $J_s$  is the equilibrium cutoff. For this reason, let me call this price the “zero-profit wage.” Notice in (30'), when the cutoff choice equals zero, and offshoring does not happen, the zero-profit wage collapses to its first regime’s value. In particular, it collapses to the skilled wage implied by equations (17) and (19).

In the following subsection, I solve for the prices of the non-offshored tasks and equilibrium cutoffs. To this purpose, I use the two equilibrium relationships between the endogenous variables: the optimal offshoring rules derived in (27) and the zero-profits conditions, displayed in equations (30') and (31'). Moreover, the wage-schedule for the domestic economy follows from feeding equations (28) and (29), the task-market clearing conditions, with the equilibrium values of these endogenous variables.

#### 4.1 Offshoring And Wage Implications

Figure 4. depicts the determination of the endogenous variables in the particular case of a strictly convex offshoring costs function.<sup>9</sup>The solid and slightly weighted curve represents this function for the first regime. The vertical intercept of the curve is  $\beta_0 t(0)$ , which denotes the offshoring costs of the cheapest-to-offshore task. As the ICT revolution hits the economy,  $\beta$  goes from  $\beta_0$  to  $\beta_1$  ( $\beta_1 < \beta_0$ ) and the offshoring costs curve shifts down. The new curve is heavy weighted and represents the second regime. In the following, I refer to this curve as “the offshoring costs curve.”

In Figure 4. the square dotted curve depicts equation (31'). In particular, it shows the relationship between the zero profit to foreign wage ratio  $\frac{w_{nt,u}(J_u)}{w_u^*}$  and cutoff choice  $J_u$ . The vertical intercept of the curve is the wage ratio implied by equations (18) and (20): the first regime’s unskilled relative wage. The circle dotted curve is the analogous relationship for skilled labor, displayed in equation (30'). Let me for now study markets equilibrium for unskilled labor.

Task-markets clear if all non-offshored tasks perceive the same wage and the wage of every offshored task equals its effective importing price. I depart from task-markets clearing in Figure 4. Equilibrium then requires two additional conditions: optimal offshoring behavior and zero profits. There is only one Point at which these conditions are jointly fulfilled. This point is the intersection of the offshoring costs and square dotted curves, denoted by  $I_u$ . Let me draw intuition on this equilibrium, for which I distinguish two regions in Figure 4.

Consider the region given by cutoff choices such that  $J_u < I_u$ . The square dotted curve is upward sloping and concave. Furthermore, the curve lies above the offshoring costs curve, which implies that the

<sup>9</sup>We do not require this second derivative to be positive over the whole range of tasks; however, it gets easy to expose the economic effects triggered by service offshoring in this case.

inequality  $w_{nt,u}(J_u) > w_u^* \beta_0 t(J_u)$  holds over the whole region. Therefore, the optimal offshoring rule is not satisfied for any  $J_u$  such that  $J_u < I_u$  and none of these choices is an equilibrium. In other words, offshoring costs are greater than “zero-profit wages” for any of these tasks, so firms have incentives to offshore these occupations. By doing so, companies make savings that reduce their marginal costs.

Several articles argue that offshoring creates domestic savings or, equivalently, increases firms’ productivity.<sup>10</sup> Let me follow a seminal paper among these articles, Grossman and Rossi-Hansberg’s setup, and call the effect of service offshoring on firms’ productivity, the *productivity effect*. The *productivity effect* is represented by the area lying above the offshoring cost function and below the square dotted curve over the region  $J_u < I_u$ . Note that this area shrinks as firms expand their set of offshored tasks; firms’ marginal savings are decreasing in the cutoff choice  $J_u$ . Hence, firms’ marginal savings are positive and decreasing over this region.

Positive and decreasing marginal savings explain why the square dotted curve is upward sloping and concave, respectively. As marginal savings are positive, firms’ marginal costs become lower. This marginal costs reduction induces a rise in the zero-profits wage, so that the square dotted curve is upward sloping. Moreover, as marginal savings are decreasing, the marginal wage increase that restores the zero-profit condition is decreasing, as well. Hence, the square dotted curve is concave.

Finally, consider the region defined by cutoff choices  $J_u$  such that  $J_u > I_u$ . As Figure 4. shows, the square dotted curve is downward sloping. If firms choose any of these tasks as their equilibrium cutoff, companies’ “disavings” cause marginal costs to increase. This marginal costs rise induces a fall in the zero-profits wage, so that the zero-profits condition is restored. Furthermore, since the inequality  $w_{nt,u}(J_u) < w_u^* \beta_0 t(J_u)$  holds for any of these tasks, the optimal offshoring rules are not fulfilled over this region either.

Firms’ optimal offshoring rules are only fulfilled at  $J_u = I_u$ : for cutoffs lower than  $I_u$ , they have incentives for moving to the right and, for cutoffs greater than  $I_u$ , they have incentives for moving to the left. Since only tasks to the left of the equilibrium cutoff are offshored, offshorability characteristics are relevant for explaining whether a task is offshored. In other words, tasks with low offshoring costs are more likely to be offshored, given their skill intensity.

Equivalently, the equilibrium for the skilled tasks is given by the intersection of the circle dotted and offshoring costs curves. Figure 4. shows that the set of offshored tasks is larger for the unskilled tasks than it is for the skilled tasks: the extensive margin is larger for unskilled labor. Since the extensive margins differ across skill-groups, skill intensities are relevant for defining whether a task is offshored. In other words, unskilled tasks are more likely to be offshored, given offshoring costs. Let me now dig deeper into the causes for different extensive margins.

Figure 4. shows that the extensive margins only differ if the vertical intercepts of the square and

---

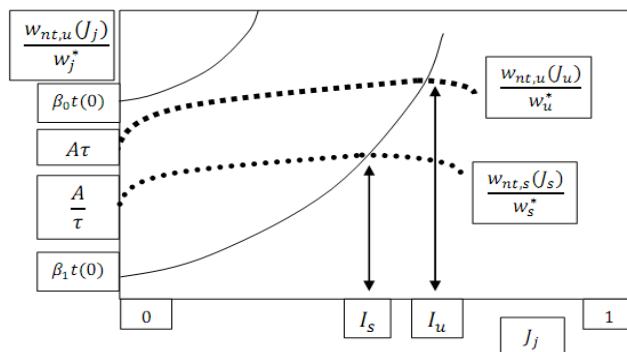
<sup>10</sup>See Heshmati (2003)[20], Olsen (2006)[30] and Amiti and Wei (2006)[3], for some examples.

circle dotted curves are different and Appendix 3. shows this result. Note that the vertical intercepts denote Home's relative wages for each skill group. Therefore, extensive margins differ because the first regime's relative wages do not equalize. Hence, the reasons for different extensive margins should be found in our discussion of the first regime.

Let me remind the reader that a necessary condition for non-relative factor prices equalization is the existence of transport costs. Given these transport costs, relative factor prices reflect that Home is a relatively skill abundant country. Therefore, Home's skill abundance explains differences in relative wages and, ultimately, differences in extensive margins across skill-groups. Hence, a factor proportion argument generate asymmetric offshoring effects. As noted in the introduction, presenting a factor proportion argument without neglecting offshorability characteristics unifies existing streams of theory.

**Figure 4.**

**Equilibrium cutoffs determination.**

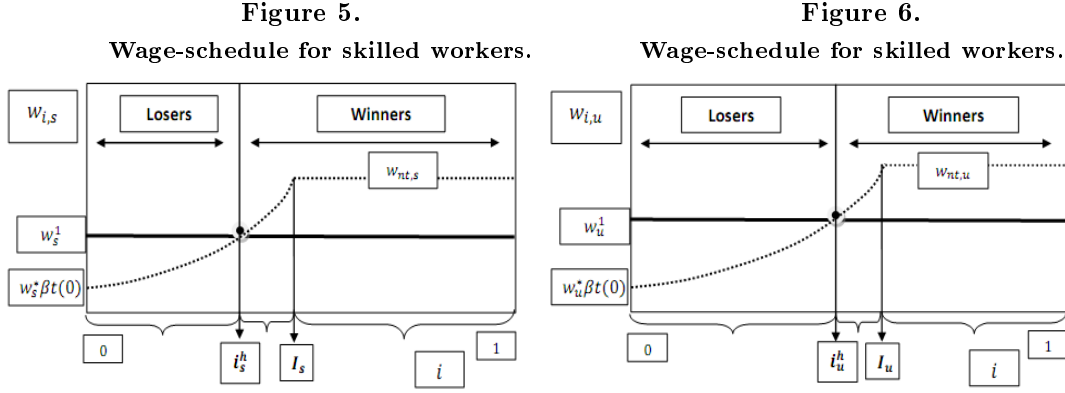


Let me now turn to the wage implications of service offshoring. To this purpose, I feed the task-market clearing conditions with the equilibrium cutoffs and wage of non-offshored task. Figure 5. displays the results for the skilled workers. The square dotted curves denote the wage-schedule for these workers and the horizontal weighted line shows their first regime's wage. The intersection between these two, indicated by a Point and a solid vertical line in Figure 5. determines the indifferent skilled occupation,  $i_s^h$ . Workers fulfilling this occupation perceive the same wage in the first and second regime. Figure 6. is the analogous for the unskilled workers.

I next draw some intuition about the impact of service offshoring on domestic wages. To this purpose, I use the *productivity* and *foreign competition effects* mentioned above. Furthermore, I distinguish three cases, each of which is indicated by a different key in Figures 5. and 6.

The first case refers to workers fulfilling non-traded tasks, who are located right to the equilibrium cutoff. As shown in both Figures 5. and 6. these workers gain from the ICT revolution because they benefit from the *productivity effect*. In other words, the technological revolution reduces domestic firms' costs and expands goods production. This output expansion shifts the demand for non-traded tasks

pushing their price up. Not surprisingly, service offshoring raises the wage of workers employed in non-offshored occupations.



The second case refers to workers employed in offshored occupations whose offshoring costs are relatively low. These workers are located further left in Figures 5. and 6. and indicated by the first key from the left. These workers lose from service offshoring as they are strongly harmed by the *foreign competition effect*. As noted in the previous subsection, firms get access to their tasks at low effective prices, so these workers' wages must fall to clear domestic markets in equilibrium.

In addition, notice in Figures 5. and 6. that the *foreign competition effect* does not act with the same intensity across offshored occupations with low offshoring costs: the cheaper it is to offshore a worker's task, the more she suffers from service offshoring. As noted in the introduction, this is an intuitive result; physicians are not expected to be equally affected by service offshoring as radiologists are.

Finally, let me consider the third case. This case refers to workers employed in offshored occupations relatively expensive to offshore. These workers are located to the left of the equilibrium cutoff and indicated by the middle keys in Figures 5. and 6. Note that these workers supply their labor in non-offshored tasks markets, such as those depicted in Figures 1. and 2. These Figures might mistakenly take us to the conclusion that the ICT revolution harms these workers; unexpectedly, these workers gain from service offshoring.

The key point is that Figures 1. and 2. do not consider the *productivity effect*, as I have imposed the output level to equal the first regime's production  $Y_j^1$ . However, these workers benefit from the *productivity effect* more than they suffer from the *foreign competition effect*. These two effects are summarized in Figure 7. which displays the market equilibrium for an offshored task  $i_j''$  with high offshoring costs. The heavy weighted curves denote the second regime's demand for task  $i_j''$ , as in Figure 2. The square dotted curves represent the same demand, as the second regime's output level  $Y_j^2 > Y_j^1$  is imposed.

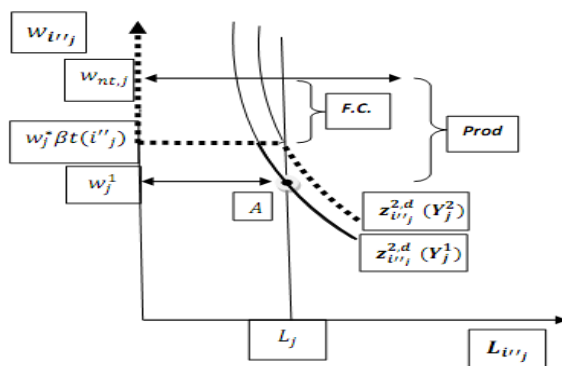
Figure 7. disentangles the *productivity* and *foreign competition effects*. To this purpose, it makes



use of a non-offshored task, whose *foreign competition effect* equals zero. The tag **F.C.** corresponds to this effect, which is given by the vertical distance between the prices of the non-offshored task and the offshored task  $i''_j$ . The tag **Prod.** refers to the *productivity effect*, given by the vertical distance between the prices of the non-offshored task in the first and second regimes -the former is also  $w^E$ , its wage from Figure 3-. Figure 7. emphasizes that offshored tasks with relatively high offshoring costs gain from service offshoring because their *productivity effect is larger than their foreign competition effect*.

**Figure 7.**

**Productivity and Foreign Competition effects.**



Let me now compare the wage-schedules for unskilled and skilled workers, given by Figures 5. and 6. Note that the proportion of skilled occupations gaining from the ICT revolution is greater than the proportion of unskilled occupations. This result matches Crino’s empirical evidence presented in the introduction. Crino found positive correlation between wage and employment changes at the occupational level. Furthermore, the probability of finding a positive employment response was increasing in skill levels, given offshoring costs. Hence, the proportion of occupations for which wages have increased is expected to increase with skill levels, as well. This is the result that yields the comparison between the considered Figures.

In addition, Figures 5. and 6. show that the proportion of occupations losing from service offshoring is larger for unskilled labor and Appendix 4. shows this result. Furthermore, there are differences in wage-losses for unskilled and skilled workers, given tradeability characteristics. In particular, unskilled losers lose more than skilled losers. Summarizing, since Home is a skill-abundant country, the ICT revolution more strongly harms unskilled workers than skilled workers.

To conclude, the comparison of the first and second regimes shows that both skill levels and tradeability features are relevant for determining whether a task is offshored. Furthermore, the two labor dimensions are relevant variables in assessing whether workers fulfilling an occupation gain or lose from the ICT revolution. In the next section, I present a simple retraining model, which allows me to find

the occupational employment responses to service offshoring. To this purpose, I feed this model with the wage-schedule displayed in Figures 5 and 6.

## 5 The Retraining Process

In this section, I present a simple retraining model, which yields the employment consequences of service offshoring I carefully study in the next section. As seen in the last section, service offshoring creates wage differences across tasks with the same skill intensity. Therefore, workers might find it profitable to invest in specific human capital and switch to a better-paid occupation. Occupation switching then yields employment responses to service offshoring: employment increases in the non-offshored tasks and falls in the offshored occupations in which there is retraining.

As for retraining, workers make two decisions. First, they decide on whether to invest in retraining or keep their old jobs. On the one hand, retraining allows workers to fulfill non-traded tasks, the occupations with the highest returns. On the other hand, retraining entails costs, so it forces retrainees to foregone part of their incomes. Second, retrainees design their retraining plans. In particular, they decide on the duration of their retraining programs  $R$ , and number of retraining hours per period,  $h^t$ .

As a preview of the results, workers' heterogeneity will generate different retraining decisions. In particular, a worker's retraining decisions will depend on her pre-ICT revolution occupation and ability to retrain. A worker's pre-ICT revolution occupation determines her value of the retraining option: the higher the wage difference between the worker's and a non-offshored occupation, the more she will be willing to retrain. Therefore, only workers whose occupations have a sufficiently low return will accomplish the human capital investment.

Furthermore, workers within the same pre- ICT revolution occupation differ in their abilities to retrain. In particular, the retraining productivities of the  $L_j$  workers fulfilling the  $j$ -skilled task  $i$  are distributed according to a c.d.f.  $g_{ij}(\cdot)$  with support  $(\underline{a}_{ij}, \bar{a}_{ij})$ , where  $g_{ij}(a^h)$  indicates the proportion of workers whose productivity is lower than  $a^h$ . I assume for now that individuals are identically distributed across tasks, then  $\underline{a}_{ij} = \underline{a}$ ;  $\bar{a}_{ij} = \bar{a}$  and  $g_{ij}(\cdot) = g(\cdot) \forall j \in (s, u) \forall i \in (0, 1)$  and  $\forall a^h \in (\underline{a}, \bar{a})$ . In other words, the first regime's labor allocation across tasks is independent of workers' retraining productivities.

The assumption on equal distributions across tasks is in line with the characteristics of my setup: a perfect competition-world, in which labor return equals its marginal productivity value and agents do not expect the ICT shock. I break the latter in Section 7. in which I introduce a public sector augmented with expectations. As I show below, this government is willing to generate an ex-ante sorting of workers across occupations.

Without loss of generality, I assume that workers' worklives equal  $T$  periods. Furthermore, in order

to simplify the decision-making process, I follow Ben-Porath's (1967) seminal paper on human capital investment. In particular, I make the same assumptions as Ben-Porath, which are the following:

1. Individual utility is not a function of activities involving time as an input.
2. An amount of time per period, normalized to 1, is allocated to activities producing earnings and retraining.
3. Complete asset markets: borrowing and lending takes place at a constant rate  $r$ .

Under these assumptions, workers base their retraining decisions on their lifetime income. Therefore, a worker retrain if and only if the discounted value of her lifetime income is greater under the retraining option than it is under the non-retraining option. Let me for now postpone the retraining-non retraining decision and analyze workers' optimal retraining programs. The decision on whether to retrain will follow from this analysis: workers designing long plans will prefer to avoid retraining and keep their old jobs.

When designing their programs, workers choose the sequence  $\{h^t\}_{t=0}^R$  and duration  $R$  that maximize their lifetime income under the retraining option. In particular, a worker employed in the  $j$ -skilled task  $i$ , whose retraining productivity is  $a_h$ , maximizes the following expression:

$$(32) \text{Max}_{\{h_{i,j}^{a_h t}\}_{t=0}^{R_{i,j}^{a_h}}; R_{i,j}^{a_h}} I_{i,j}^{a_h, Ret} = \int_0^{R_{i,j}^{a_h}} (1 - h_{i,j}^{a_h t}) [w_j^* \beta t(i)] e^{-rt} dt + \int_{R_{i,j}^{a_h}}^T w_{nt,j} e^{-rt} dt$$

where  $I_{i,j}^{a_h, Ret}$  is the worker's lifetime income under the retraining option,  $h_{i,j}^{a_h t}$  is her amount of retraining hours in period  $t$  and  $R_{i,j}^{a_h}$  is the amount of periods the worker chooses for her retraining plan. Equation (32) shows the trade-off faced by the retrainee when allocating the fixed amount of time per period. As the worker allocates more of her time to retraining, she speeds the retraining process. However, she must then spend fewer hours at work  $-(1 - h_{i,j}^{a_h t})$ , which reduces her labor income for that period.

The retraining technology is given by a C.E.S. learning production function. Retrainees complete their process as they "produce"  $\theta$  effective retraining hours. Therefore, the worker mentioned above maximizes equation (33) subject to the following constraint:

$$(33) \theta = Q_{i,j} = a_h \left[ \int_0^{R_{i,j}^{a_h}} (h_{i,j}^{a_h t})^\rho dt \right]^{\frac{1}{\rho}}$$

where  $Q_{i,j}$  indicates the worker's number of effective hours and  $\rho < 1$  is a parameter of the production function, which measures the sensitivity of the learning process to the length of the retraining program. This learning-production function implicitly assumes two characteristics on retraining. First, the efficiency of the learning process increases with the duration of the retraining program. Let me call this characteristic the "Cramer Assumption." This assumption relies on a realistic thought: knowledge is

better assimilated when spread over time, so “cramers” must spend more hours to obtain the same retraining result. Second, the marginal productivity is decreasing in hours, for a given a given period  $t$ . In other words, retrainees become tired after a long learning session, so they produce less effective retraining per actual hour. Since marginal productivity is decreasing, no worker designs a one-period plan in equilibrium.

When building her plan, the worker faces a time-constraint on its duration: no retraining program can last more than  $T$  periods, the length of any worker’s lifetime. I abstract from this constraint when solving the optimization problem, but I impose it to the unconstrained solution displayed below. Given these considerations, the optimal sequence  $\left\{ h_{i,j}^{a^h t} \right\}_{t=0}^{R_{i,j}^{a^h}}$  is characterized by the following first order conditions:

$$(34) \lambda_{i,j}^{a^h *} = \frac{w_j^* \beta t(i)}{a_h} \left[ \left( \frac{1-\rho}{r\rho} \right) (e^{R_{i,j}^{a^h} \left( \frac{r\rho}{1-\rho} \right)} - 1) \right]^{-\left( \frac{1-\rho}{\rho} \right)}$$

$$(35) h_{i,j}^{a^h t^*} = \frac{\theta}{a_h} \left[ \left( \frac{1-\rho}{r\rho} \right) (e^{R_{i,j}^{a^h} \left( \frac{r\rho}{1-\rho} \right)} - 1) \right]^{-\frac{1}{\rho}} e^{\frac{rt}{1-\rho}}$$

Equation (34) displays the cost of the marginal effective retraining hour  $\lambda_{i,j}^{a^h *}$ . Due to the implicit “Cramer Assumption”, this cost is decreasing in the length of the retraining process. The intuition goes as follows: the longer the plan duration, the fewer the total amount of hours the worker spends to retrain. Equation (35) displays the optimal number of hours in terms of the duration, for a given period  $t$ . In order to find this duration in equilibrium, let me plug equation (35) into the lifetime income definition displayed in (32). I then obtain an expression which depends only on  $R_{i,j}^{a^h}$ . Maximizing this expression yields the following choice:

$$(36) e^{-rR_{i,j}^{a^h}} [w_{nt,j} - w_j^* \beta t(i)] = \frac{\theta w_j^* \beta t(i)}{a_h} r^{\frac{1}{\rho}} \left[ \frac{1-\rho}{\rho} \right]^{-\left[ \frac{1-\rho}{\rho} \right]} e^{R_{i,j}^{a^h} \left[ \frac{r\rho}{1-\rho} \right]} \left[ e^{R_{i,j}^{a^h} \left[ \frac{r\rho}{1-\rho} \right]} - 1 \right]^{-\frac{1}{\rho}}$$

Equation (36) illustrates the trade off faced by a retrainee when choosing the duration of her plan. The *LHS* of the equation shows the disadvantage of a long retraining process. As the plan duration increases by one period, the worker incorporates later into her new better-paid occupation. She then benefits one fewer period from the wage differential. The *RHS* of the equation shows the advantage of a long retraining plan. As the duration increases by one period, the marginal cost of effective retraining falls. The worker then foregoes less income during her retraining process.

Furthermore, there are workers designing so long retraining plans that their lengths cannot be found using equation (36). For these workers, the marginal benefit from enlarging the plan is greater than the

marginal cost at any  $R_{i,j}^{a^h} \in R$ . Therefore, if these workers lived an infinite amount of time, they would design perpetual retraining programs. Since perpetual programs are not feasible, I force these workers to design  $T$ -period retraining plans. As shown in Appendix 5. this is their best strategy, conditional on choosing the retraining option. More formally, I impose the following:

$$(37) \quad R_{i,j}^{a^h*} = T \quad \text{if} : \frac{w_{nt,j}}{w_j^* \beta t(i)} < 1 + \frac{\theta}{a^h} r^{\frac{1}{\rho}} \left[ \frac{1-\rho}{\rho} \right]^{-[\frac{1-\rho}{\rho}]}$$

Equation (37) defines the set of workers whose plan length do not solve equation (36). As noted above, I set these lengths to  $T$ . Notice in equation (37), the inequality becomes less restrictive as the  $i$  index rises. Therefore, employees in this set tend to work in offshored occupations with high offshoring costs. In addition, the inequality becomes less restrictive as the zero-profit to foreign wage ratio falls. Consequently, the proportion of tasks “falling” in the set is greater for skilled labor than it is for unskilled labor.<sup>11</sup> In other words, a higher proportion of skilled occupations is in the set.

Let me for now exclude the set defined in (37) and concentrate on the rest of workers. These workers’ plan lengths are obtained from equation (36) and written as follows:

$$(38) \quad \text{if} : -\left[\frac{1-\rho}{r\rho}\right] \text{Ln}\left[1 - \frac{r\left[\frac{\rho}{1-\rho}\right]^{1-\rho}}{\left[\frac{\theta}{a^h} \left[\frac{w_{nt,j}}{w_j^* \beta t(i)} - 1\right]\right]^\rho}\right] = B_{i,j}^{a^h} \leq T \quad R_{i,j}^{a^h*} = B_{i,j}^{a^h}$$

$$\text{Otherwise} \quad R_{i,j}^{a^h*} = T$$

Statement (38) is composed by two lines. The first line corresponds to workers whose retraining programs are shorter than their lifetime. The lengths of these workers’ programs depend on their retraining productivity and pre-ICT revolution occupation. In particular, more productive workers design short retraining plans. Furthermore, unskilled workers and employees fulfilling low-offshoring costs-occupations finish their retraining processes faster. These workers are “in a rush” to end their retraining course because they benefit from a high wage differential by switching occupations.

The second line of statement (38) corresponds to workers designing retraining plans longer than their lifetime. In this line, there is a higher proportion of skilled tasks and employees tend to work in high offshoring costs occupations. The lengths of their retraining programs are not feasible, even though they can be found using equation (36). Consequently, I impose these programs to last  $T$  periods, which, as shown in Appendix 5. is their best strategy, conditional on choosing the retraining option.

Let me now turn to the retraining-non-retraining decision. As noted above, workers retrain *if and only if* their lifetime income is greater under the retraining option than it is under the non-retraining

<sup>11</sup>Because  $\frac{w_{nt,s}}{w_s^*} < \frac{w_{nt,u}}{w_u^*}$ , as shown in the previous section.

option. A worker's lifetime income under retraining is defined by equations (37) – (38), which I next use to calculate the income difference between the two options. For the worker mentioned above, this difference is the following:

$$(39) I_{i,j}^{a^h,Ret} - I_{i,j}^{a^h,NoRet} = \left[ \frac{w_{nt,j} - w_j^* \beta t(i)}{r} \right] [e^{-R_{i,j}^{a^h} * [\frac{r}{1-\rho}]} - e^{-rT}]$$

where  $I_{i,j}^{a^h,NoRet}$  is the worker's lifetime income under the non-retraining option. From equation (39), we know that this worker retrains *if and only if*:

$$(40) R_{i,j}^{a^h} * < T[1 - \rho]$$

Equation (40) states that only workers with sufficiently short retraining programs decide to retrain. Therefore, retrainees tend to work in low-offshoring costs-occupations. Furthermore, tasks in which there is retraining tend to be unskilled occupations. For these workers, retraining is profitable because their “after-retraining lifetime” is sufficiently long to recover the human capital investment. Moreover, notice that workers whose programs are forced to last  $T$  periods, defined in (37) and the second line of (38) and employed in high-offshoring costs occupations, prefer not to retrain.

Besides, equation (40) states that the proportion of tasks in which there is retraining is higher for skilled tasks than it for unskilled occupations. To the purpose of developing intuition for this result, let me derive the condition under which there is retraining in an occupation. There is retraining in the  $j$ -skilled task  $i$  if at least the most productive workers accomplish the human capital investment. More formally, this statement is written as follows:

$$(41) R_{i,j}^{\bar{a}} * \leq T[1 - \rho]$$

If equation (41) is not fulfilled, there is not retraining in this occupation because the plans of less productive workers are longer than the program of the most productive employees. Furthermore, since the length of a retraining plan is continuously increasing in tasks' offshoring costs, equation (41) implicitly defines  $j$ -cutoffs, under which there is retraining. Let me call these cutoffs “retraining cutoffs”, which I display in Appendix 6. and recover from the following expression:

$$(42) R_{\bar{I}_j}^{\bar{a}} * = T[1 - \rho]$$

where  $\bar{I}_j$  is the  $j$ -skilled retraining cutoff task. The cutoffs are increasing in the zero-profit to foreign wage ratio and the intuition goes as follows: a ratio increase makes retraining more profitable, so workers

retrain in a larger proportion of occupations. The implication of this result is that the set of occupations losing employment is greater for unskilled tasks than it is for skilled occupations. In other words, the extensive margins for occupations losing employment is greater for unskilled labor. In the next section, I use this statement when summarizing the model’s employment predictions.

## 6 Summary Results

In this section, I use the retraining cutoff tasks to study the model’s employment predictions. Next, I show how these predictions relate to the empirical evidence presented in Section 2. Finally, I match the employment predictions to the wage changes found in Section 5. Figure 8, displayed below, summarizes the results of the model.

The predictions I next present are about employment adjustments on the extensive and intensive margins of the occupations. As for the extensive margins, the cutoff traded and retraining tasks should be considered. As for the intensive margins, we should focus on equation (40).

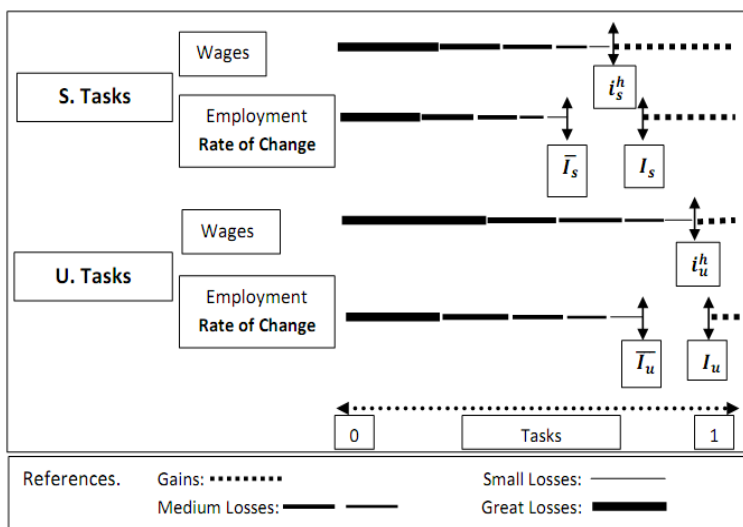
The extensive margins defining the occupations for which offshoring raises employment are determined by the cutoff traded tasks. Figure 8. depicts the sets of occupation that gain employment by skill groups. The sets are indicated by the square dotted lines located further right on the continuums labeled “Employment.” Note that the square dotted lines refer to the most expensive to offshore tasks: employment increases in these occupations. This prediction is consistent with articles suggesting that service offshoring generate employment gains for the offshoring countries. In particular, it is consistent with employment gains for the expensive-to-offshore occupations. Furthermore, the set of occupations with a positive response is greater for the skilled tasks than it is for the unskilled tasks, as indicated by a larger square dotted line on the upper continuum. In other words, this paper predicts that the two labor dimensions are relevant for understanding the effects on service offshoring. This result matches Crino’s empirical evidence showing that the probability of a positive employment response increased with skill intensities, given offshorability features.

The extensive margins defining the occupations for which offshoring reduces employment is determined by the retraining cutoff tasks. In Figure 8. the sets of occupations that lose employment are indicated by solid lines with different weights. Note that the proportion of occupations losing employment is greater for the unskilled tasks than it is for the skilled tasks: the unskilled retraining cutoff task is lower, as discussed at the end of the last section. This prediction matches the empirical evidence suggesting that service offshoring creates employment losses for easily offshorable occupations. Furthermore, this result matches the evidence presented in Crino’s article, in which the negative employment responses were concentrated among the unskilled occupations.

In addition, the article makes predictions about the employment adjustment on the intensive margins. These adjustments are expressed in rates of change and indicated by different weights in Figure 8. As we move left on the continuums, the lines become heavier weighted: easily offshorable occupations have higher rates of employment losses. The proof for this result is given by equation (40). Notice in this equation, the proportion of workers fulfilling the inequality decreases with tasks' offshoring costs. Furthermore, this proportion is greater for unskilled labor, given two occupations with the same offshoring costs. Hence, this model predicts that the rates of employment losses are greater for unskilled occupations, given tradeability characteristics.

Let me now turn to the wage-results. As depicted in Figure 8. unskilled tasks are more likely to have losers than skilled occupations. In addition, Figure 8. replicates Section 4.'s results: unskilled losers lose more than skilled losers, given offshoring costs. However, losers and winners are not fully determined by their skill group: employees suffering from wage losses tend to work in low offshoring costs occupations. Finally, Figure 8. shows that the model matches the little empirical evidence on wage-responses because it generates positive correlation between wages and employment changes at the occupational level.

**Figure 8.**  
Summary of results.



## 7 Extension: The Role Of Public Policy

This section aims to link expectations on the ICT shock to ex-ante outcomes. In this attempt, I do not fully characterize the equilibrium of an offshoring model with forward-looking agents. Moreover, deriving such an equilibrium might require a large departure from this setup. However, this paper provides a simple



benchmark to describe some channels through which expectations and ex-ante outcomes are connected. Therefore, I use this benchmark to study public policy implications for a well-informed forward-looking government. Hence, the goal of this section is two-fold: to establish a link between expectations and ex-ante outcomes and to study the role of public policy.

Several authors argue that the ICT revolution requires a change in the direction of public policy over two dimensions: educational policy and welfare programs. As for educational policy, these authors claim that providing more traditional education is not the right answer to the ICT revolution. In particular, Krugman (2011)[24] argues that college degrees do not guarantee good jobs and Blinder (2009)[10] claims that a college degree “may no longer be a panacea.”<sup>12</sup> According to these authors, educational policy should instead provide students with high retraining skills<sup>13</sup> and knowledge to fulfill hardly-tradeable occupations. This article shows that retraining skills are relevant and that hardly tradeable-occupations have the highest returns. Hence, this paper supports Krugman, Blinder and Baldwin’s ideas.

As for welfare programs, these authors claim that public policy should provide a safety net and seriously engage in retraining programs. The content I present in this section should be placed in this public policy dimension. I follow Baldwin, who argues that public policy should protect workers rather than sectors, and consider a worker-specific transfer system. Furthermore, I follow Blinder, who proposes an improvement of federal job training programs, and search for a transfer system that improves the efficiency of the retraining process. Hence, I make an efficiency argument for a welfare program.

In the following, I study the transfer system carried out by the well-informed forward-looking government. In particular, I analyze the labor allocations this government aims to implement. Among the feasible allocations,<sup>14</sup> the Pareto efficient maximize aggregate lifetime income, given occupations’ total employment levels. In other words, a transfer system allows the government to implement a sorting of workers across tasks, such that aggregate income is maximized. I next search for necessary conditions on the sorting of workers, so the considered allocations are Pareto efficient. Even more important, these allocations represent Pareto improvements with respect to the market-induced allocation, displayed in Section 3.

We are now ready to dig into the analytics. To the purpose of finding the lifetime income maximizing allocation, let me distinguish two sets of tasks. First, consider the set of tasks in which workers do not retrain. In this set, there are non offshored tasks. Furthermore, there are offshored tasks because some of these occupations are associated to perpetual retraining plans, independent of workers’ productivities. In particular, consider workers’ lifetime incomes in this set. These lifetime incomes are written as follows:

---

<sup>12</sup>Along these lines, Baldwin (2006)[5] does not think that governments should prepare students for more analytic jobs.

<sup>13</sup>By retraining skills I refer to the “flexibility” mentioned by these authors.

<sup>14</sup>By feasible allocations, I mean allocations that can be implemented through the transfer system

$$(42) I_{i,j}^{a^h, NoRet} = \frac{w_{nt,j}}{r} [1 - e^{-rT}] \quad \forall i \geq I_j \quad \forall j \in (s, u)$$

$$(43) I_{i,j}^{a^h, NoRet} = \frac{w_j^* \beta t(i)}{r} [1 - e^{-rT}] \quad \forall i \leq I_j \text{ with no retraining} \quad \forall j \in (s, u)$$

Equation (42) refers to a worker employed in a non-offshored task and equation (43) refers to a worker fulfilling an offshored task, in which no worker retrains. Note that these workers' incomes do not depend on their retraining productivities.

Second, consider now the set of tasks composed by the rest of occupations, in which at least one worker retrains. This set is non-empty because the government lets some retraining happen when maximizing aggregate income.<sup>15</sup> The lifetime income of any of these retrainees is written as follows:

$$(43) I_{i,j}^{a^h, Ret} = \frac{w_j^* \beta t(i)}{r} - \frac{w_{nt}}{r} e^{-rT} + \left[ \frac{w_{nt,j} - w_j^* \beta t(i)}{r} \right] e^{-R_{i,j}^{a^h} * \left[ \frac{r}{1-\rho} \right]}$$

$$\forall i \leq I_j \text{ with retraining} \quad \forall j \in (s, u)$$

Notice in equation (43) that  $\frac{dI_{i,j}^{a^h, Ret}}{da^h} > 0$ : a retrainee's lifetime income rises with her retraining productivity, as a higher productivity reduces the duration of her plan. Therefore, workers' incomes are affected by retraining productivities in the second set of tasks. Since incomes are not affected by productivities in the first set, this leaves room for a Pareto improving policy. In particular, the government can increase aggregate lifetime income by assigning high-retraining productivity workers to the set of retraining-occupations and low-retraining productivity workers to the set of non-retraining occupations. More formally, let me state:

**Characterization:** *If a labor allocation is Pareto efficient, the workers with the lowest productivities are assigned to the tasks in which retraining does not happen. Furthermore, allocations in which these workers are assigned to non-offshored tasks and occupations with perpetual plans are weakly Pareto efficient allocations.*

Notice that going from Section 3's to a Pareto efficient allocation has redistribution implications. In particular, some of the most retraining productive workers are worse off because they are taken from non-offshored to offshored occupations. However, the transfer system allows the government to compensate these workers. In particular, the government should collect taxes from the least productive workers and transfer some of the tax revenue to the most productive employees.

<sup>15</sup>The reason being that workers retrain only if retraining increases their lifetime incomes.

Besides, note that the characterization displayed above does not require any assumption. However, the characterization has nothing to say about the sorting of workers across occupations in which retraining takes place. In the following, I offer a finer characterization. In particular, I investigate the conditions under which conditions high productivity workers should be assigned to tasks in which retraining tends to occur more often -occupations with large wage differentials-. Let me call this property, “the decreasing monotone property” because productivities decrease as we move towards high- $i$  occupations, in these allocations.

On the one hand, a government implementing these allocations raises retraining productivity in low- $i$ -occupations, which induces a fall in the programs lengths associated to these tasks.<sup>16</sup> On the other hand, this policy induces productivity falls and plan duration increases in high- $i$ -occupations. Therefore, the productivity relocation is income maximizing if the income rise for the low- $i$  occupations<sup>17</sup> more than compensates the income loss for the high  $i$  tasks. In other words, a decreasing monotone allocation is lifetime income maximizing when  $\frac{dI_{i,j}^{a^h, Ret}}{da^h di} < 0$ . Appendix 7 shows that this condition holds *if and only if*:

$$(44) \sigma = \frac{1}{\rho} > \frac{w_{nt,j}}{w_j^* \beta t(0)}$$

where  $\sigma$  measures the sensitivity of a worker’s retraining expenditure to the length of his retraining plan. As understood from the learning production function displayed in (33), the greater this measure, the more sensitive this worker’s retraining expenditure is. Equation (44) ensures that the induced income rise in the lowest- $i$  occupations is sufficiently large. This holds if the expenditure of workers employed in these occupations, and then their lifetime incomes, are sufficiently sensitive to  $R$ . In particular, a higher sensitivity guarantees that the income rise induced by a lower  $R_{i,j}$  in the low- $i$  tasks more than compensates the income fall induced by a higher  $R_{i,j}$  in the high- $i$  occupations.

Finally, let me comment on the transfer system that would implement the allocations mentioned in this section. This system pursuits two goals: to ensure that every agent is better off and to generate the right incentives so that workers sort into the desired occupations. To this respect, the transfer system is suitable for a broader interpretation. In particular, an unemployment insurance system would fulfill the same goals, if it is properly tailored. Therefore, a government that is able to distinguish workers’ productivities can tailor the system and generate Pareto improvements. An interesting question then is how asymmetric information alters the efficiency of public policy in this context. I propose this question as a line for further research, in the next section.

---

<sup>16</sup>With respect to the allocation in Section 3.

<sup>17</sup>-induced by a lower plan duration-

## 8 Conclusion and Lines For Further Research

The ICT revolution allowed for trade in services and unfinished goods at low transportation costs. Therefore, the revolution altered the form of international competition, which currently happens among individuals, and not among firms from countries with comparative advantages in different sectors. This paper approaches theory to empirical work on the effects of the ICT revolution.

In particular, this article shows that old theory tools can be combined with modern frameworks in approaching theory to a heated empirical debate. Empiricists debate on which the relevant characteristics for an occupation's propensity to be offshored are. Some authors argue that skill intensities are more important than tradeability characteristics and call the old comparative advantage law to understand employment losses. A different stream argues that the ICT revolution caused heterogeneous offshoring costs reductions within occupations of similar skill intensities. This stream highlights the role of tradeability characteristics and claims that a considerable amount of offshorable jobs will be lost to service offshoring. However, recent empirical evidence unifies the two streams for the U.S. white-collar population, as it claims that tradeability and skill characteristics are relevant. In this model, the two labor characteristics determine an occupation's propensity to be offshored. Furthermore, the two dimensions determine the employment implications of service offshoring at the occupational level. Hence, this paper rationalizes recent empirical evidence on employment.

Furthermore, reconciliation between theorists and empiricists requires a wage-employment model, which I have proposed. Besides rationalizing evidence on employment, the model addresses a theorists' concern, which has been inherited from the old Stolper-Samuelson tradition. In particular, the model claims that skilled workers are more likely to benefit from wage rises, and unskilled workers more likely to suffer from wage-losses. Therefore, this paper answers the question on who loses from trade in terms of wages. However, wage responses to service offshoring are not fully explained by skill-levels, which makes the results more intuitive and consistent with the little empirical evidence on occupational wages.

Much work remains to be done on the economic effects of the ICT revolution. On the empirical side, the main constraint is the availability of data. There is little work on the service offshoring implications for developing countries. In particular, it would be interesting to observe the behavior of occupational wages for large service exporters, such as India or China. This behavior might define development strategies for these countries.

Furthermore, this paper opens up a line of research linking expectations on the ICT revolution and ex-ante outcomes. This link has not been exploited. Moreover, the link is of a great importance, given that the ICT revolution occurred in the 1990's, a period of frequent economic changes, in which the information already flowed at a high speed. In this context, it seems hard to argue that agents were myopic and did not form any expectations on the ICT shock. Particularly interesting would be to study

how a decentralized mechanism can generate different ex-ante outcomes when every agent is forward looking. In addition, the article questions the role of public policy in the context of an ICT world. Many questions remain to be answered on this role. As mentioned above, it would be particularly interesting to see what the role of information in shaping this role is.

## References

- [1] D. Acemoglu, P. Antràs, and E. Helpman. Contracts and technology adoption. *The American economic review*, pages 916–943, 2007.
- [2] M. Amiti and S.J. Wei. Fear of service outsourcing: is it justified? *Economic Policy*, 20(42):308–347, 2005.
- [3] M. Amiti and S.J. Wei. Service offshoring and productivity: Evidence from the US. *The World Economy*, 32(2):203–220, 2009.
- [4] D.H. Autor, L.F. Katz, and M.S. Kearney. Trends in us wage inequality: revising the revisionists. *The Review of Economics and Statistics*, 90(2):300–323, 2008.
- [5] R. Baldwin. Globalisation: the great unbundling (s). *Economic Council of Finland*, 20, 2006.
- [6] S.O. Becker, K. Ekholm, and M. Muendler. Offshoring and the onshore composition of occupations, tasks and skills. *CEPR Discussion Papers*, 7391, 2009.
- [7] J. Bhagwati, A. Panagariya, and TN Srinivasan. The muddles over outsourcing. *The Journal of Economic Perspectives*, 18(4):93–114, 2004.
- [8] A.S. Blinder. Offshoring: the next industrial revolution? *Foreign affairs*, 85(2):113–128, 2006.
- [9] A.S. Blinder. How Many US Jobs Might be Offshorable? *World Economics*, 10(2):41–78, 2009.
- [10] A.S. Blinder. Offshoring: big deal, or business as usual? *Offshoring of American jobs. What response from US economic policy*, pages 19–60, 2009.
- [11] R. Crinò. Offshoring, multinationals and labour market: A review of the empirical literature. *Journal of Economic Surveys*, 23(2):197–249, 2009.
- [12] R. Crinò. Service Offshoring and White-Collar Employment. *Review of Economic Studies*, 77(2):595–632, 2010.
- [13] R.J.C. Daron Acemoglu et al. *Essays on International economics by Sergi Basco*. PhD thesis, Massachusetts Institute of Technology, 2010.
- [14] A.V. Deardorff. A trade theorist’s take on skilled-labor outsourcing. *International Review of Economics & Finance*, 14(3):259–271, 2005.
- [15] R.C. Feenstra and G.H. Hanson. Globalization, outsourcing, and wage inequality. *American Economic Review*, 86(2):240–245, 1996.
- [16] C. Freund and D. Weinhold. The Internet and international trade in services. *American Economic Review*, 92(2):236–240, 2002.
- [17] N. Gregory Mankiw and P. Swagel. The politics and economics of offshore outsourcing. *Journal of Monetary Economics*, 53(5):1027–1056, 2006.

- [18] G.M. Grossman and E. Rossi-Hansberg. The rise of offshoring: its not wine for cloth anymore. *The New Economic Geography: Effects and Policy Implications*, pages 59–102, 2006.
- [19] G.M. Grossman and E. Rossi-Hansberg. Trading tasks: a simple theory of offshoring. *American Economic Review*, 98(5):1978–1997, 2008.
- [20] A. Heshmati. Productivity growth, efficiency and outsourcing in manufacturing and service industries. *Journal of Economic Surveys*, 17(1):79–112, 2003.
- [21] G. Kambourov and I. Manovskii. Occupational mobility and wage inequality. *Review of Economic Studies*, 76(2):731–759, 2009.
- [22] G. Kambourov and I. Manovskii. Occupational specificity of human capital\*. *International Economic Review*, 50(1):63–115, 2009.
- [23] W. Kohler. International outsourcing and factor prices with multistage production. *Economic Journal*, pages 166–185, 2004.
- [24] P. Krugman. Degrees and dollars. *NYTimes. com, March*, 6:2011, 2011.
- [25] R.E. Lipsey. Measuring international trade in services. *NBER Working Paper*, 2006.
- [26] K.E. Lommerud, F. Meland, and O.R. Straume. Can deunionization lead to international outsourcing? *Journal of International Economics*, 77(1):109–119, 2009.
- [27] J.R. Markusen. Modeling the Offshoring of White-Collar Services: From Comparative Advantage to the New Theories of Trade and Foreign Direct Investment. In *Brookings Trade Forum*, volume 2005, pages 1–23. Brookings Institution Press, 2006.
- [28] J.R. Markusen and B. Strand. Trade in business services in general equilibrium, 2007.
- [29] J.P. Neary. Theory and policy of adjustment in an open economy. *CEPR Discussion Papers*, 1985.
- [30] K.B. Olsen. *Productivity impacts of offshoring and outsourcing: A review*. Citeseer, 2006.
- [31] M. Ritter. Offshoring, trade in tasks and occupational specificity of human capital. *Manuscript, Temple Univ*, 2008.
- [32] P.A. Samuelson. The transfer problem and transport costs: the terms of trade when impediments are absent. *The Economic Journal*, 62(246):278–304, 1952.
- [33] D. Trefler. Service offshoring: Threats and opportunities. In *Brookings Trade Forum*, volume 2005, pages 35–60. Brookings Institution Press, 2006.
- [34] D. Trefler and Canada. Industry Canada. *Policy Responses to the New Offshoring: Think Globally, Invest Locally*. Citeseer, 2006.
- [35] D. Van Welsum and G. Vickery. Potential offshoring of ict-intensive using occupations. *DSTI Information Economy Report, OECD, Paris*, 2005.

## 9 Appendices

- Appendix 1.

This Appendix shows that when Home is a large country, Home's wage rates can be solved in terms of countries' labor endowments, technologies and the transportation cost measure. When Home is a large country, the relative price of the skill-intensive good must equate Home's excess supply to foreign's excess demand augmented by the transport cost measure. If consumers have identical Cobb-Douglas preferences, and considering countries' supplies given in equations (12)–(15), this market-clearing condition is written as follows:

$$AL_s - \alpha \frac{I}{p^T} = \tau \left[ \alpha \frac{I^*}{\tau p^T} - L_s^* \right]$$

where  $I = A[p^T L_s + \tau L_u]$  and  $I^* = [\tau p^T L_s^* + L_u^*]$  are countries' incomes under (17) – (20) and balanced trade.

Then the relative price that solves for market clearing is:

$$p^T = \left[ \frac{\alpha}{1 - \alpha} \right] \left[ \frac{A\tau L_u + L_u^*}{AL_s + \tau L_s^*} \right]$$

; therefore:

$$w_s =, \text{ then : } A \left[ \frac{\alpha}{1 - \alpha} \right] \left[ \frac{A\tau L_u + L_u^*}{AL_s + \tau L_s^*} \right]$$

and

$$w_u = A\tau$$

- Appendix 2.

This appendix shows that all j-skilled tasks must have the same price in equilibrium. If there were at least one task  $i'_j$  with a strictly higher price in equilibrium, the supply of the remaining tasks would be zero. However, no demand for a task is zero, unless its price goes to infinite. Moreover, the price of tasks  $i_j \neq i'_j$  cannot go to infinite, as there is at least one task  $i'_j$  with a larger price i. Consequently, there cannot be any task  $i'_j$  with a strictly higher price in equilibrium: all tasks must have the same price.



- Appendix 3.

This Appendix shows that if  $\frac{w_s}{w_s^*} < \frac{w_u}{w_u^*}$ , then  $I_u^* > I_s^*$ . First, evaluate the expression  $\frac{w_{nt,j}(J_j)}{w_j^* \beta t(J_j)}$  in both sectors at  $I_u$ :

$$\frac{w_{nt,u}(I_u)}{w_u^* \beta t(I_u)} = e^{\left[ \frac{\ln(\frac{w_u}{w_u^*}) - \ln(\beta) - \int_0^{I_u} \ln((i))}{1 - I_u} \right]} = 1 < \frac{w_{nt,s}(I_u)}{w_s^* \beta t(I_u)} = e^{\left[ \frac{\ln(\frac{w_s}{w_s^*}) - \ln(\beta) - \int_0^{I_u} \ln((i))}{1 - I_u} \right]}$$

where the inequality for the low-skilled case comes from the definition of equilibrium and the inequality from  $\frac{w_s}{w_s^*} < \frac{w_u}{w_u^*}$ .

It follows from the inequality that  $I_u^* \neq I_s^*$ , then either  $I_u^* > I_s^*$  or  $I_u^* < I_s^*$ . To find this out, take the derivative of  $\frac{w_{nt,s}(J_s)}{w_s^* \beta t(J_s)}$  with respect to  $J_s$ , and find:

$$\frac{w_{nt,s}(J_s)}{w_s^* \beta t(J_s)} \left[ \frac{\ln(\frac{w_{nt,s}(J_s)}{w_s^* \beta t(J_s)})}{1 - J_s} - \frac{t'(J_s)}{t(J_s)} \right]$$

As  $t'(J_s)$  is non-strictly positive for  $J_s > I_u$ , this shows that  $\frac{w_{nt,s}(J_s)}{w_s^* \beta t(J_s)}$  decreases for any  $J_s > I_u$ , and the equilibrium cannot be in that region.

- Appendix 4.

This Appendix shows that there are more winners and fewer losers for the high-skilled case. The worker  $h$  employed in task  $i$  and sector  $j$  who earns the same wage rate with respect to the first regime is defined as follows:

$$w_j^* \beta t(i_j^h) = w_j \iff \frac{w_j}{w_j^*} = \beta t(i_j^h)$$

Since we have that  $\frac{w_s}{w_s^*} < \frac{w_u}{w_u^*}$ , then  $i_s^h < i_u^h$ , there are more losers among the low-skilled workers.

- Appendix 5.

This Appendix shows that the best strategy for workers whose retraining programs are longer than  $T$  periods in the unconstrained problem is to set the duration to  $T$ . Consider the F.O.C. displayed in (36). The marginal net benefit from increasing the duration of the program is:

$$\frac{\theta w_j^* \beta t(i)}{a_h} r^{\frac{1}{\rho}} \left[ \frac{1 - \rho}{\rho} \right]^{-\left(\frac{1-\rho}{\rho}\right)} \left[ 1 - e^{-R_{i,j}^{a_h} \left(\frac{r}{1-\rho}\right)} - 1 \right]^{-\frac{1}{\rho}} - e^{-r R_{i,j}^{a_h}} [w_{nt,j} - w_j^* \beta t(i)]$$

The two terms  $\frac{\theta w_j^* \beta t(i)}{a^h} r^{\frac{1}{\rho}} [\frac{1-\rho}{\rho}]^{-(\frac{1-\rho}{\rho})} [1 - e^{-R_{i,j}^{a^h} (\frac{r}{1-\rho})} - 1]^{-\frac{1}{\rho}}$  and  $e^{-r R_{i,j}^{a^h}} [w_{nt,j} - w_j^* \beta t(i)]$  are monotonically decreasing in  $R_{i,j}^{a^h}$ . Therefore, the marginal net benefit from enlarging the plan longer is positive for  $R_{i,j}^{a^h} < R_{i,j}^{a^h*}$ . Hence, the worker can keep enlarging the program and obtain a higher utility while  $R_{i,j}^{a^h} < T < R_{i,j}^{a^h*}$ .

- Appendix 6.

This appendix derives the  $j$ -skilled retraining cutoff task. Using equations (38) and (41), the  $j$ -skill retraining cutoff task solves the following:

$$-\left[\frac{1-\rho}{r\rho}\right] Ln\left[1 - \frac{r\left[\frac{\rho}{1-\rho}\right]^{1-\rho}}{\left[\frac{\theta}{\beta} \left[\frac{w_{nt,j}}{w_j^* \beta t(i)} - 1\right]\right]^\rho}\right] = T[1 - \rho]$$

; therefore:

$$\hat{i}_j = t' \left( \left[ \frac{w_{nt,j}}{w_j^* \beta} \right] \left[ \frac{\left[\frac{\theta}{\beta} [1 + e^{Tr\rho}]\right]^{\frac{1}{\rho}}}{\left[\frac{\theta}{\beta} [1 + e^{Tr\rho}]\right]^{\frac{1}{\rho}} + \left[r\left[\frac{\rho}{1-\rho}\right]^{1-\rho}\right]^{\frac{1}{\rho}}}\right] \right)$$

- Appendix 7.

This Appendix shows that the increase in a worker's lifetime income induced by a higher productivity decreases with  $i$ , under condition (44). Taking derivatives, one obtains the following:

$$\frac{dI_{i,j}^{a^h, Ret}}{da^h di} = \frac{\rho \left( (w_j^* \beta t(i) - w_{nt,j}) r \rho - (1 - \rho) (w_j^* \beta t(i) - w_{nt,j} \rho) \left[ \frac{a^h \rho}{\theta(1-\rho)} \left[ \frac{w_{nt,j}}{w_j^* \beta t(i)} - 1 \right] \right]^\rho - \frac{r \left[ \frac{\rho}{1-\rho} \right]^{1-\rho}}{\left[ \frac{\theta}{\beta} \left[ \frac{w_{nt,j}}{w_j^* \beta t(i)} - 1 \right] \right]^\rho} \right) e^{-R_{i,j}^{a^h*} \left[ \frac{r}{1-\rho} \right]}}{w_j^* \beta \left( r \rho - (1 - \rho) (w_j^* \beta t(i) - w_{nt,j} \rho) \left[ \frac{a^h \rho}{\theta(1-\rho)} \left[ \frac{w_{nt,j}}{w_j^* \beta t(i)} - 1 \right] \right]^\rho \right)^2}$$

If condition condition (44) holds, this expression is negative for every  $i$ .