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Female labor Force Participation in an Era of Organizational and Technological Change

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Abstract

This paper examines the endogenous interaction between the rise in female labor force participation and changes in both the method and mode of production that occurred during the early part of the 20th century. Within a dynamic general equilibrium framework, an exogenous expansion in the skill level of the population induces an organizational change at the firm level and a redirection of investment towards new technologies that complement the skills of the emerging workforce. In addition to allowing for a change in the method of production in a market with directed technical change, a framework is developed to explicitly examine the transitional dynamics as skilled workers become relatively abundant. The rise in the skill level explains the rise in female labor force participation, the increase in women's wages and the decline of the clerical wage relative to manufacturing.

Keywords: female labor force participation; technological change; organizational change; clerical work.

1 Introduction

> "A reason for believing that the Nation's labor force will continue to increase in size is the striking increase during recent decades in the number and proportion of women - particularly of married women - in the labor force. During the 40 years from 1900 to 1940 the proportion of all women 14 years old and over in the labor force increased from approximately 20.4% to 25.7%, and the proportion of married women 15 years and over in the labor force increased from approximately 5.6% to 15.1%. This movement of women into the labor force cannot be considered temporary. Its magnitude and it's momentum are too great, its causes too elemental. It will continue." [Alba Edwards, 1943]

1.1 The analysis

Female labor-force participation was not purely a post-war phenomena. In fact, the foundations of the post-war exodus of women from the home to the workplace were laid much earlier in the century. This paper presents a dynamic general equilibrium model which relates the increase in female labor force participation to three, critical, changes in the economy: increased skill levels of the population; increased division of labor in administration; and the rapid adoption of new technologies. As education levels increased at the end of the 19th century, firm structure changed in order to profit from the growing number of skilled workers. Tasks at the managerial level became more specialized and work that had been previously undertaken by a few educated managers was now undertaken by many skilled clerical workers. Growth in employment in this sector was accompanied by an acceleration in the adoption of technologies used by clerical workers. As male workers held the comparative advantage in manual labor, new clerical positions were occupied predominantly by educated, female, workers. Increases in the productivity of clerical workers prevented the wages of these workers from falling, as their supply grew, and clerical employment continued to expand over time. The dynamics in this early period set the stage for the post-war surge in female employment, and the biggest labor force transition in the twentieth century.

1.2 Historical Facts

1.2.1 Education

Prior to the first half of the century, few women were employed in the waged workforce and sparsely available public schools meant that few individuals, male or female, had the opportunity to obtain formal schooling above the elementary level. Secondary school attendance and graduation rates began rising steadily near the end of the 19th century and grew rapidly between 1910 and 1940. In 1900 only 6.3% of 17 year old Americans had graduated from high school, by 1915 this number grew to 12.8%, and in 1925 to 24.4%. By 1940 the U.S. high school graduation rate had increased to a historically unprecedented 49.0%.[1]

Many factors have been attributed to inducing this rise in educational levels; the declining cost of transportation, increasing agricultural productivity, legislation prohibiting child labor, curriculum changes, as well as increased corporate demand for literate, and numerate, workers.[2] While the demand for skilled workers may have been responsible for increases in education levels, there are several reasons to believe that the causation runs in the other direction. The foundation for large scale high school enrollment preceded the large increases in graduation *rates* seen in the 1920's and 1930's, and appears to have begun as early as 1870. While the number of female graduates is marginally higher in every decade than male graduates, rapid growth in the number of male high school graduates cannot be supported by increasing demand for clerical workers, as most of this demand was filled by female workers. Electrification and innovation in manufacturing could have created an excess demand for skilled male workers, but it is equally plausible that the causation runs in the opposite direction: increasing availability of skilled workers, both male and female, led to increases in the adoption of technologies that utilized the available skills and, in the case of the clerical workers, induced a restructuring of the firm to incorporate those skills into the production technology.

Figure 1 illustrates a relationship between the growth of high school graduation rates and changes

[1]For information on U.S. school enrollment and high school graduation rates see Series H419 and H599 in the U.S. Historical Statistics (1975).

[2]For more information on the expansion of high school enrollment and graduation rates in the US see Goldin (1999).

in female labor force participation for the nine census divisions for the period 1910 to 1940. Regions with the largest increase in high school graduation rates were the same regions with largest increase in the proportion of the workforce that were female. Other regions, predominantly in the south, which experienced only minor increases in high school graduate rates experienced negative growth in female labor force participation.

1.2.2 Organizational Change

This growth in education levels coincided with a widespread restructuring of production. At the end of the nineteenth century jobs could be divided roughly into two categories: manual labor and managerial labor. The majority of jobs fell into the first category and were performed primarily by men with little or no education. Managerial tasks were performed by a small number of educated men, often the owners of the firm. By the 1890's firms began to undertake a division of labor at the administrative level; employing multiple managers aided by a host of clerical workers to performed the day-to-day administrative tasks. These clerical jobs required a relatively high level of education but none of the specialized training of highly skilled jobs or the physical endurance of unskilled jobs. Workers moved into these positions directly out of high-school, with the majority of these new positions being filled by female workers.[3] The share of female workers employed as clerical workers grew from 4% in 1890 to 21% in 1930; and by 1930, 50% of all clerical workers were female, up from 15% in 1890 (Goldin, 1990). This trend continued in the second half of the century; by 1980 35% of all female workers were employed as clerical workers and 78% of clerical workers were female.[4]

1.2.3 Technology

The first thirty years of the twentieth century are notable for rapid innovation and adoption of office technologies.[5] Typewriters, duplicators and bookkeeping machines became commonplace by 1910 as did new construction methods for office buildings. New technologies required the general literacy and numeracy

[3] See Goldin (1990) pp 106 - 107 for an excellent description of division of labour in the clerical sector in this period.

[4] Author's calculations from IPUMs 1900 to 2000 using all workers 18 to 65 in the labour force.

[5] As an example, in 1899 total value of bookeeping machinery produced was less that $6 million total. By 1919 the value of output of these technologies exceeded $83 million. (Strom, 1989)

skills of the new high school graduates and contributed to the division of labor in administration (Kwolek-Folland, 1994: 29). Mills (1951: 193) argues that the increased availability of office technologies stemmed directly from the increased adoption of these technologies; rates of which were driven by other factors beyond supply: "Thus machines did not impel the development, but rather the development demanded machines, many of which were actually developed especially for tasks already socially created." (Strom, 1986: 73)

1.3 Description of the model

In the model a final good is produced using two complementary inputs: manufactured goods and administrative services. Suppliers of the inputs to administrative services choose to use one of two organizational modes, one in which skilled workers are a factor of production and one in which they are not. The relative profitability of organizational modes determines whether or not suppliers to administrative services use skilled labor. Additionally, the relative rate of return to investing in technology in the production of administrative services relative to technology in the production of manufactured goods determines the rate at which technologies are adopted in either sector. If the organizational mode which uses no skilled labor is used, increases in the skill level of the population (both male and female) decrease the profitability of investing in intermediate inputs in administration relative to manufactured goods. If the hiring of skilled workers becomes profitable, however, investing in administration becomes relatively profitable and technology in that sector increases.

The introduction of a rising skill level in a model in which economic rents determine both the organizational structure and the relative rates of technical adoption leads to complex transitional dynamics in the growth of the economy. For example, human capital growth influences the rate of technology adoption in the sector in which it is employed by influencing the profitability of investing in that sector. It also influences the rate of technology adoption in the sector in which it is not employed both directly, through the redirection of investments away from that sector, and indirectly, through the complementarity of inputs. In addition, both human capital growth *and* the relative rate of technical adoption influence the profitability of hiring clerical workers in administrative services and, as such, the rate at which firms adopt

the new organizational structure. Finally the choice of organizational structure feeds back into the relative profitability of investing in intermediates and influences the relative rate of technical adoption between sectors. All of these factors determine both relative and absolute levels of the wage in the administrative sector and determine the rate at which labor demand increases over time.

1.4 Related Literature

Economists have rejected the notion that this increase in female labor force participation is purely a post-war phenomena. Smith and Ward (1985) compare cross-sectional profiles of females and find that

> "The most important conclusion to be derived from these cohort-specific profiles is that the causes of growth in the female work force had their roots very early in the century, and even in the nineteenth century...The remarkable transformation of American women at work cannot simply be viewed as a result of changes in attitudes or in the labor markets that have taken place exclusively since World War II." (Smith and Ward, 1984; p.g. 62)

Smith and Ward find that the most significant increases in participation in the first half of the century were by young, married women; between 1920 and 1940 the labor force participation of this group[6] doubled from 9.7% to 20%. In 1900, married women paid a large penalty in terms of forgone wages in finding employment that was consistent with home life. Their wages in that period were 30% lower than those of single women. Over the next half century this wage differential between married and unmarried women essentially disappeared.

Goldin (1983) argues that increases in school rates for young women and the growth of the clerical sector are central to the growth in the female labor supply over the same period. Her work is consistent with Smith and Ward; she finds that in every generation from the 1855 cohort and onward that labor force participation increased within marriage. She attributes this change to increasing education rates, decreasing fertility rates and changes in the occupational, and earning, opportunities for women. Growth in the clerical sector presented new employment opportunities for married women which were easier to

[6] age 25-34

reconcile with home life. Goldin suggests that "an extensive participation of married women in the labor force had to await the emergence of such an occupation." Smith and Ward support this view and argue that the "large growth in demand for clerical workers is the most likely cause of the shift upward in women's relative wages and the dissipation of the married wage penalty."

Recent literature has revived the debate on the basis of this movement of women into waged employment at the beginning of the century.[7] Earlier work (Mincer, 1962; Smith and Ward, 1984) conclude that women increased their labor supply in response to increases in wages paid to, and demand for, female workers. Rotella (1977) determines that both demand and supply played a role in increased female employment; as the supply of educated female workers grew so did the demand for clerical workers, driven particularly by technological advances. Rotella (1981) argues that the adoption of new technologies reduced the skill-specific requirement for clerical jobs and led to an increase in demand for female workers. Goldin and Katz (1995) find that from 1890 to 1920 both the demand and supply of high-school educated workers increased and that starting in the 1920's demand expanded, outpacing supply, and as a result the relative wage paid to skilled workers began to stabilize. They attribute this increase demand to rapidly expanding office technologies that "enabled the substitution of educated workers and machines for the exceptionally able."

More recently, Adshade and Keay (2007) find that relative to their male counterparts, weekly wages earned by female workers, particularly female clerical workers, were stagnant between 1914-1925, but rose substantially thereafter. Using biannual data for the state of Ohio from 1914 to 1937 they conclude that technological change among Ohio's manufacturing industries was biased towards the use of female clerical labor throughout the period and that directed technological and organizational change among U.S. manufacturers was induced by the presence of a pool of educated female workers. That is, in response to declining relative wages of female, skilled workers, firms reorganized and adopted new technologies in order to exploit those same resources.

[7] In addition to the theoretical literature there have been many excellent texts written on the movement of women into workforce and the growth of the clerical sector at the beginning of the century. Interested readers are recommended to consider: Davies (1982), Erickson (1934), Goldin (1990), Kwolek-Folland (1994), Nelson (1975), Rotella (1977) and Strom (1992).

Greenwood, Seshadri and Yorukoglu (2005) argue that women's labor force participation at the turn of the century can be explained by increases in the supply of household durable goods and innovation in the sector that provided substitutes to home production, concluding that labor force participation rates rose steadily over the last century as prices of these goods declined. Within that framework women were effectively 'pushed' into waged employment by exogenously falling prices of durable goods. An increase in the supply of female workers, holding the demand for those workers constant, implies that the female wage should be falling monotonically relative to male workers. As noted above (Adshade and Keay (2007)), the wages for female workers - both production and clerical - relative to male workers did not decline monotonically over the 1900-1940 period. This suggests that if there was an increase in the supply of female workers, there must have been concurrent change in the demand for those same workers and women were effectively 'pulled' into the waged labor market at the same time as they were 'pushed' from the home.

The outline of this paper is as follows. The following section presents the basic model. The third section gives a definition of the equilibrium and the fourth section characterizes it. The fifth section examines how female labor demand evolves through each phase of the economy and details the transitional dynamics. The paper concludes with a simulation of the model. A list of variables and their definitions follows the conclusion. All proofs are given in technical appendices available on the author's website.

2 The Model

2.1 The Structure of the Firm

Consumption goods are produced by a large number of competitive firms each producing identical output. Each individual firm has an integrated organizational structure consisting of three levels of production. Producers in every level of production behave as individual profit maximizing firms. Each level of production is discussed in detail below and a diagram with the organizational structure of the firm is in Figure (2).

2.1.1 Final Good Production:

Final good, Y, is produced using constant elasticity of substitution production technology with intermediate inputs "Goods" (G) and "Administration" (A). The production function for firm i is given by:

$$Y_i = \left[\nu G_i^{\rho} + (1-\nu)\, A_i^{\rho}\right]^{1/\rho}. \tag{1}$$

The constant elasticity of substitution between G and A is $\sigma = \frac{1}{1-\rho}$. It is natural to assume that G and A are gross complements in the production of Y, that is $\sigma < 1$ or $\rho < 0$.[8] As firms are competitive and symmetric with constant returns to scale, the subscript i can be dropped.

2.1.2 Goods and Administration Production:

Goods and Administration are in turn produced using multiple, differentiated, intermediate inputs and production technology:

$$A = \left[\int_0^{M_A} {x_{A,j}}^{\alpha} dj\right]^{1/\alpha} \text{ and } G = \left[\int_0^{M_G} {x_{G,j}}^{\alpha} dj\right]^{1/\alpha}. \tag{2}$$

The measure of these intermediate inputs in each sector are M_A and M_G and the output of intermediate j, in sectors A and G, is $x_{A,j}$ and $x_{G,j}$. Intermediate inputs enter the production functions of G and A in such a way that there are increasing returns to scale. As the variety of intermediates increases, total factor productivity of all inputs increases; as tasks become more specialized (and intermediates more numerous) output of G and A increases proportionally faster than the increase in resources allocated to production.

2.1.3 Production of Intermediate Inputs:

Intermediate Inputs to Manufactured Goods The intermediate inputs used in the production of G and A are the output of individual technologies. The intermediate inputs to Goods represent manufactured output that are produced through physical effort, or *brawn* type jobs. The intermediates to Administration are non-manufactured or service-type output that is produced through skill, or *brain* type jobs. Each *technology* exists prior to the beginning of the period in which it is utilized and, as such, suppliers of

[8] This assumption is fitting given the context and the specific nature of the two sectors considered. None of the main results of the paper depend on it however. The main results of the paper, with this assumption dropped, are considered in Appendix E.

these intermediates are technology 'adopters' rather than 'innovators'.[9] Each intermediate requires a fixed investment and earns monopoly profits in the first period in which it is produced. Technology is adopted for one period, after which it becomes obsolete and is replaced by new technologies.

Each of the M_G intermediates used in the production of Goods is produced by combining its unique technology with labor. The supplier of intermediate j pays wage $w_{G,j}$ per *efficiency unit* of labor input and sells their output to the producer of G for $p_{G,j}$. The level of output when labor is combined with technology j is:

$$x_{G,j} = \theta l_j, \tag{3}$$

where l_j represents the efficient units of labor input to intermediate j in the production of G and θ is labor productivity.

Intermediate Inputs to Administrative Services Each of the M_A intermediate inputs used in the production of Administration can be produced using one of two modes of production: an 'old' mode of organization or a 'new' mode of organization. The old mode of organization uses no labor input. Output with this mode of organization is:

$$x_{A,j} = \theta. \tag{4}$$

The new organizational mode uses the labor of skilled workers. Output when the new mode of organization employed is:

$$x_{A,j} = \theta n_j. \tag{5}$$

where n_j is the efficient units of labor input when when technology j is used.

In every period, where M_A is the level of intermediate inputs to sector A, there are $\widetilde{M}_A$ intermediate inputs using the new organizational mode and $M_A - \widetilde{M}_A$ intermediate inputs using the old mode of organization.

[9] In the sense that it is the rate of adoption of new technologies in each sector that determines the outcome of the model, rather than innovations. The terms 'technology' and 'capital' are interchangeable here.

2.2 The Household

The economy consists of a large number of households within an overlapping generations framework. Each household consists of two members, one male and one female.[10] The number of households in each generation is normalized to one and individual households have zero measure. Households live for two periods with preferences over consumption of market produced goods and home produced goods:

$$U(h, c_t, c_{t+1}) = \begin{cases} \overline{h} + \ln(c_t) + \beta \ln c_{t+1} & \text{if } h \geq \overline{h} \\ -\infty & \text{if } h < \overline{h} \end{cases}, \tag{6}$$

where c_t is consumption of a market produced good Y, in period t, β is the discount factor and h is the consumption of household goods and services.

Each individual in the household is endowed with one unit of labor. Individuals allocate their labor between household production and market labor. Time spent working is non-divisible; the labor of each member is supplied either to the market or the home but not to both. The production of $\overline{h}$ units of the household good requires the input of exactly one unit of labor when produced at home. If both units of labor are supplied to market, the household good must be purchased on the market. Since final goods are the numeraire, the price of the household good equals unity.[11]

The total wage income of the household in period t, I_t, is a function of the total labor sold on the market, and s_t is the savings of the household in period t. When only one member of the household supplies labor to the market, the budget constraint is:

$$c_t + s_t = I_t, \tag{7}$$

and when both supply their labor:

$$c_t + s_t = I_t - \overline{h}. \tag{8}$$

In either case the household supplies no labor to the market in the second period and the budget constraint

[10] By assuming that the household is made of only two individuals - one male and one female - I am assuming the simplest possible household structure. An alternative way to consider this framework is to assume there are two types of workers, one of whom has a comparative advantage in the production of manufactured goods. Using the male/female is notation is consistent, however, with the 'feminization' of clerical work in this period.

[11] This too is a simplifying feature of the model; one that could be generalized to allow for relative price changes between home produced and other consumption goods.

is:

$$c_{t+1} = (1 + r_{t+1})s_t \tag{9}$$

Households allocate consumption over time by maximizing (6) subject to (7) and (9) when one member of the household supplies labor to the labor market, and subject to (8) and (9) when both members supply labor to the labor market. Given log linear preferences this yields savings in the first period given by:

$$s_t = \begin{cases} \frac{\beta}{1+\beta}\left(I_t - \overline{h}\right) & \text{if both work} \\ \frac{\beta}{(1+\beta)} I_t & \text{otherwise} \end{cases} . \tag{10}$$

Time subscripts are dropped where there is no ambiguity.

2.3 Human Capital

Individuals in this economy can be either skilled or unskilled.[12] The *potential* aggregate human capital supplied by male workers given the stock of unskilled male workers, L_u^m, and skilled male workers, L_s^m, is:

$$H^m = a_u L_u^m + a_s L_s^m, \tag{11}$$

where a_u denotes efficiency units of unskilled male labor and a_s efficiency units of skilled male labor.

The potential human capital supplied by female workers (i.e. if all women choose to work in the waged workforce) given the stock of unskilled female workers, L_u^w, and skilled female workers, L_s^w, is:

$$H^w = b_u L_u^w + b_s L_s^w, \tag{12}$$

where b_u denotes efficiency units of unskilled female labor and b_s efficiency units of skilled female labor.

Skilled workers are more productive ($a_s > a_u$ and $b_s > b_u$) and male workers have a comparative advantage in employment in the production of the intermediate to G.[13] To simplify the analysis I set $a_u = b_u = 0$ in the Administrative sector, so that employment in the production of the intermediate

[12] Where workers are skilled in the sense that they possess the basic level of literacy and numeracy skills attributed to individuals who have completed, or nearly completed, a high school education.

[13] Where $\{a_u^G, a_s^G, b_u^G, b_s^G\}$ are the productivity parameters on labour in production of G and where $\{a_u^A, a_s^A, b_u^A, b_s^A\}$ are the productivity parameters on the labour in the production of A, then

$$\frac{a_s^G}{a_s^A} > \frac{b_s^G}{b_s^A} \tag{13}$$

imposes this condition.

inputs to A is restricted to skilled workers. No restrictions are placed on the absolute advantage of workers.

The wage at which skilled female workers are indifferent between supplying labor to the household and supplying skilled labor to the market is $\overline{w}$ where;

$$\overline{w} = \frac{\overline{h}}{b_S^A}. \tag{14}$$

Finally, male human capital grows at rate g^M and female human capital grows at rate g^W.

3 Definition of Equilibrium

The following conditions determine the equilibrium in every period. The first section determines the conditions under which firms that are behaving optimally allocation investment between the Goods and Administration sectors when the capital market is clearing, and when households take the measure of suppliers using the new mode of organization as given. The second section determines the optimal decision of suppliers of intermediate inputs to Administration of the mode of organizational choice when suppliers take the level of investment in the sector as given. Conditions required for the division of occupation by gender are determined in the third section.

3.1 Conditions on The Relative Rate of Technology Adoption

In each period, the relative rate of technology adoption in the Goods and Administration sectors is determined by equating profits across sectors and by equating investment in new technologies to savings from the previous period. Households make investment decisions in every period taking the measure of suppliers to A using the new mode of organization as given.

- Capital market clearing implies that investment in each period is equal to savings from the previous period. If γ is the cost of a technology in both sectors and $M_{G,t+1}$ and $M_{A,t+1}$ are the measure of intermediate inputs in period $t+1$, total investment equals total savings (S_t) when:

$$\gamma M_{G,t+1} + \gamma M_{A,t+1} = S_t. \tag{15}$$

- No-arbitrage conditions are such that the return to investment must be equal across sectors. The relative rate of technology adoption in the Goods and Administration sectors is determined by equating profits ($\pi_{G,t}$ and $\pi_{A,t}$) across sectors. This condition is simply:

$$\frac{\pi_{G,t}}{\gamma} = \frac{\pi_{A,t}}{\gamma} = 1 + r_{t-1}. \tag{16}$$

- The return to investing in technology M_G is:

$$\pi_G = \nu\,(1-\alpha)\,(\theta l)^{\alpha}\,Y^{1-\rho}G^{\rho-\alpha}, \tag{17}$$

where the derived demand for goods is $G = \theta l M_G^{\frac{1}{\alpha}}$.

- The return to investing in technology M_A that uses the old mode of organization is:

$$\pi_A^O = (1-\nu)\,\theta^{\alpha}Y^{1-\rho}A^{\rho-\alpha}. \tag{18}$$

where the derived demand for administration is $A = \theta\left[\widetilde{M}_A n^{\alpha} + \left(M_A - \widetilde{M}_A\right)\right]^{\frac{1}{\alpha}}$.

- The return to investing in technology M_A that uses the new organizational mode is:

$$\pi_A^N = (1-\nu)\,(1-\alpha)\,(\theta n)^{\alpha}\,Y^{1-\rho}A^{\rho-\alpha}. \tag{19}$$

When $\widetilde{M}_A < M_A$ (such that some producers use the old mode of organization) it must be the case that $\pi_A^N \leq \pi_A^O$, profits in the new mode are at most equal to profits in the old mode for a given level of human capital. If the reverse were true no supplier would use the old mode of organization. When $\widetilde{M}_A = M_A$, and all suppliers find it profitable to use the new organizational mode, then $\pi_A^N > \pi_A^O$. The no-arbitrage condition in (16) holds when $\pi_A^O = \pi_G$, if $\widetilde{M}_A \leq M_A$, and $\pi_A^N = \pi_G$, when $\widetilde{M}_A = M_A$. These conditions on the relative rate of technology adoption determine the level of investment in a sector in each period.

3.2 Conditions on the Choice of Organizational Mode of Production

Suppliers choose the organizational mode taking the level of technology in sector A as given. The profitability of the new mode of organization is determined by both the level of potential female human capital and the market wage. If the potential demand is such that the market wage falls below the reservation

wage then this mode is not feasible. If the potential demand is such that the market wage exceeds the reservation wage, a supplier will still only use the new organizational mode if the available supply of available human capital is sufficiently high to make production relatively profitable.

- A single deviating supplier choosing the new organizational mode earns profits:

$$\pi_A^N(\overline{w}) = (1-\nu)(1-\alpha)\left(\left(\frac{\alpha\theta}{\overline{w}}\right)^{\alpha} Y_t^{1-\rho} A_t^{\rho-\alpha}\right)^{\frac{1}{1-\alpha}}. \tag{20}$$

- The existence of an equilibrium in which at least one supplier deviates to the new organizational mode requires that $\pi_A^O < \pi_A^N(\overline{w})$. Using (18) and (20) this condition can be expressed as :

$$\overline{w} < \alpha\theta^{\alpha}\left((1-\nu)(1-\alpha)\right)^{\frac{1-\alpha}{\alpha}} Y^{1-\rho} A^{\rho-\alpha}. \tag{21}$$

- If demand is such that the market wage meets or exceeds the reservation wage, the condition on the division of labor in the production of intermediate inputs to A is met when:

$$\pi_A^N \geq \pi_A^O. \tag{22}$$

3.3 Condition on Male labor Not Entering the Administration Sector

The necessary condition required when male workers do not enter the clerical workforce is given by:

$$\frac{a_s^G}{a_s^A} w_G > w_A > \overline{w}. \tag{23}$$

4 Characterization of Equilibrium

The level of technology adoption in Goods and Administration is determined by equating profits across sectors and equating investment in new technologies to savings, taking the level of suppliers using the new mode of production as given. The measure of suppliers using the new mode of organization, on the other hand, is a function of the market wage, the reservation wage, and the availability of skilled workers, taking the level of investment in that sector as given. In equilibrium, households choose the optimal allocation of investment across sectors conditional on the *anticipated* measure of suppliers using the new mode of organization. Subsequently suppliers of intermediate inputs choose the optimal mode of

organization conditional on household investments. The solution to the equilibrium can be characterized by three equations: one in which the measure of producers using the new mode determine the level of investment in administration, a second in which the availability of labor determines the measure of producers choosing the new mode of organization and a third which determines the level of technology and measure of producers using the new mode of organization when the wage is exactly the reservation wage.

In order to provide a stationary representation of the equilibrium it convenient to deflate all variables by male human capital H^m, such that

$$m_{A,t} = \frac{M_{A,t}}{H_t^m}, \tag{24}$$

$$\widetilde{m}_{A,t} = \frac{\widetilde{M}_{A,t}}{H_t^m}, \tag{25}$$

$$s_t = \frac{S_t}{H_t^m}, \tag{26}$$

$$a_t = \frac{A_t}{H_m}, \tag{27}$$

$$\chi_t = \frac{M_{G,t}}{H_t^m}. \tag{28}$$

4.1 Relative Technological Adoption (RTA)

The first equation maps out the relationship between the overall level of technology invested in the administration sector and the anticipated measure of producers using the new mode of production when the rate of return to investment in administration is equated to the rate of return to investment in goods. Producers using the new organizational mode produce more output per unit of technology than producers using the old mode. A marginal increase in the measure of suppliers using the new mode increases average output of technologies in that sector. This puts downward pressure on the return to investing in that sector relative to the goods sector and the relative investment in administration declines. An RTA curve is determined by deflating the profit functions for goods (17) and administration (18) by male human capital and substituting into the no-arbitrage condition in (16).[14] The resulting function is downward

[14] And noting that $l = \frac{H^m}{M_G}$; all male human capital is employed by M_G suppliers of intermediates.

sloping and is implicitly defined by:

$$m_{A,t} = \left(\frac{1}{1-\alpha}\frac{1-\nu}{\nu}\right)^{\frac{\alpha}{\alpha-\rho}} \chi_t^{\frac{\alpha-\rho+\alpha\rho}{\alpha-\rho}} - \widetilde{m}_{A,t}\left(n_t^{\alpha}-1\right). \tag{RTA}$$

An RTA curve is illustrated in Figure (3).

4.2 Marginal Human Capital (MHC)

The second equation maps out the upper bound on the measure of suppliers using the new mode of organization conditional on the available labor supply. There is a unique, minimum, level of labor input (per supplier) at which suppliers find it profitable to switch from using the old to using the new mode of production. As long as the level of aggregate labor input is such that at least some suppliers find it profitable to use old mode of production, each supplier will using exactly this minimum input. If not, and the level of labor is such that suppliers are able to increase their labor input above this level, then suppliers using the old mode could profitability switch to the new mode of production and the no-arbitrage conditions would not be met. The MHC is along the 45° line at all points at which all suppliers could use the mode of organization without being constrained by the supply of skilled labor. Above this level the curve is horizontal at the measure of suppliers who could produce using the minimum labor input given the aggregate available labor supply. It follows that the where the minimum input of labor which satisfies the condition profits using the new mode is greater than profits using the old mode is

$$\tilde{n} = \left(\frac{1}{1-\alpha}\right)^{\frac{1}{\alpha}},$$

the maximum measure of intermediate inputs using the new organizational mode is:

$$\widetilde{m}_A\left(n_t, H_t^w, H_t^m\right) = \begin{cases} (1-\alpha)^{\frac{1}{\alpha}}\dfrac{H^w}{H^m} & \text{if } \widetilde{m}_A < m_A \\ n_t^{-1}\dfrac{H_t^w}{H_t^m} & \text{if } \widetilde{m}_{A,t} = m_{A,t} \end{cases}. \tag{MHC}$$

An MHC curve is illustrated in Figure (3).

4.3 Characterization of the Equilibrium with RTA and MHC

At every point along RTA the condition on the relative rate of technology adoption is satisfied for a given measure of suppliers using the new mode of production. Where the wage paid to workers in administration

is a continuous, increasing function of level of investment in technologies in the sector, at every point along the RTA there is a unique wage at which suppliers would be willing to hire workers. Where χ_t is the level of technology used in the production of goods per unit of human capital employed in that sector, the following lemma shows that under certain conditions the wage paid in the clerical sector is decreasing in the measure of suppliers using the new mode. That is both that, the labor demand curve is downward sloping and that the wage increases as we move down and along the RTA curve.

Lemma 1: *There exists an initial level of technology per unit of human capital in Goods,* χ_0*, such that if* $\chi_t > \chi_0$*, then the clerical wage,* w_A*, is decreasing in* $\widetilde{m}_A$*, when* $\widetilde{m}_A < m_A$*.*

Proof: See Appendix A.

Proposition 1: *The proportion of suppliers in the Administration sector who would choose to switch to the new organizational mode and pay exactly the reservation wage,* $\overline{w}$*, is increasing in the level of male human capital given the conditions in Lemma 1.*

Proof: See Appendix B.

4.4 Reservation Wage (MRW)

The level of demand at which a single deviating supplier switches to the new organizational mode is a function of the level of the reservation wage and can be implicitly defined using equation (21). The curve MRW plots the measure of suppliers using the new mode when the wage is exactly equal to the reservation wage for each level of technology. The point at which the MRW curve intersects the RTA curve determines the point along the RTA at which the wage is equal to exactly the reservation wage. By Lemma 1 at every level of technology above that level the wage is greater than the reservation wage. At every level of technology below that level the wage is less than the reservation wage. Alternatively, if the measure of producers using the new mode of organization where greater than the level where the MRW curve intersects the RTA curve, the wage would be below the reservation wage and no labor would be employed. An MRW curve is illustrated in Figure (3).

5 Evolution of Female labor Demand

Female labor demand evolves over time. As human capital grows the conditions on profitability between the sectors and between organizational modes determine the rate at which suppliers in the administration sector adopt new technologies that utilize skilled labor. Allowing human capital to grow, and by computing the equilibrium levels of investment in each sector and the proportion of suppliers using the new organizational mode in every period, the evolution of female labor demand can be traced over time. I consider four phases of the economy over which the level male and female human capital are growing. In the first phase, the level of human capital is low. The wage at which a single supplier would be willing to switch to the new organizational mode is below the reservation wage. No supplier uses the new organizational mode and no women work. In the second phase, some suppliers find it profitable to switch and pay exactly the reservation wage. The measure of suppliers that adopt the new organizational mode is below the measure at which all female workers are employed. The level of human capital employed falls below the potential level of human capital. In the third phase, the market wage is bid up above the reservation wage. All suppliers that find it profitable to use the new organizational mode, and pay $w_A > \overline{w}$, do so. The measure of suppliers who switch in this phase is constrained by the supply of skilled workers. In phase four, the level of female human capital is sufficiently high that all suppliers use the new organizational mode, pay $w_A > \overline{w}$ and employ $n > \widetilde{n}$ workers.

5.1 Phase One: No-Clerical Employment

A phase one equilibrium is illustrated in Figures (4) and (5). In phase one, the point along RTA at which the wage is equal to the reservation wage falls falls below the x-axis; every point along RTA above the x-axis the market wage is below the reservation wage. The level of human capital and savings is such that the level of demand for female workers is insufficient to meet the condition that $w_A > \bar{w}$ and no producer chooses to use the new organizational mode. Figure (5) illustrates the equilibrium outcome in phase one in a supply/demand framework. The supply of labor to the sector is a function of female human capital and is equal to zero at all levels of the wage below $\overline{w}$. At wages above $\overline{w}$ the labor supply is perfectly

inelastic.[15] The labor demand curve lies below $\overline{w}$ for every level of employment. The equilibrium outcome is on in which no clerical workers are employed.

In phase one, no technology employs clerical workers. Substituting $\widetilde{m}_{A,t} = 0$ into (RTA), the measure of intermediate inputs in A is proportional to the measure of intermediate inputs in G such that:

$$m_{A,t} = \left(\frac{1}{1-\alpha}\frac{1-\nu}{\nu}\right)^{\frac{\alpha}{\alpha-\rho}} (\chi_t)^{\frac{\alpha-\rho+\alpha\rho}{\alpha-\rho}}, \tag{29}$$

and the relative rate of growth in sector A is given by the expression:

$$\frac{\dot{m}_A}{m_A} = \frac{\alpha-\rho+\alpha\rho}{\alpha-\rho}\frac{\dot{\chi}}{\chi}. \tag{30}$$

The parametric term on the right hand side of the equation is the point elasticity of substitution between m_A and m_G in the production of final goods in phase one. It is a function of the level of complementarity between the sectors (measured by ρ) and the returns to specialization in individual sectors (measured by α). Where $\alpha > 0$ and $\rho < 0$, growth in Goods will be accompanied by positive, but proportionally slower, growth in Administration.

Proposition 2: *There exists a $\chi_t^1 > \overline{\chi}_t$, such that if $\chi_t \geq \chi_t^1$, i) an equilibrium exists in which no suppliers use the new organizational mode, and in that equilibrium both ii) the variety of intermediate inputs in G is growing proportionally faster than human capital (χ is increasing over time)* and *iii) the growth rate of intermediate inputs in Administration is slow relative to that in Goods.*

Proof: See Appendix C.

Given the conditions in Proposition 1, in phase one χ_t is increasing as human capital increases. Given the relationship between m_A and χ in (30), the curve RTA shifts up and to the right when human capital increases. If for a given increase in savings and human capital, RTA intersects the x-axis at a point at which $\chi \leq \overline{\chi}_t$, then $w_{A,t} > \overline{w}$ and the economy is no longer in phase one.

[15] This zero elasticity assumption is consistent with Goldin's (1990) reported estimates of the elasticity of female labour supply in this period.

5.2 Phase Two: Partial Clerical Employment and Surplus Female Human Capital

In phase two, the condition on the reservation wage now holds with equality; at least one supplier in A chooses to deviate to the new organizational mode and pay exactly $\overline{w}$.

Figures (6) and (7) illustrates the equilibrium in phase two. An increase in savings has shifted both RTA and MRW up and to the right. The increase in human capital is such that now $w_A^1 > \overline{w}$ and $w_A^3 < \overline{w}$. At least one supplier can profitably deviate to the new organizational mode and pay a wage equal to exactly the reservation wage.

As Figure(7) illustrates, with higher levels of human capital, labor demand is greater at every level of the wage. The level of employment in this sector is now determined by the point at which the labor demand curve intersects the labor supply curve at $w_A = \overline{w}$. Some, but not all, potential female labor is employed.

5.3 Phase Three: Partial Clerical Employment and No Surplus Human Capital

The equilibrium in Phase Three is illustrated in Figures (8) and (9). Again, an increase in savings has shifted both RTA and MRW up and to the right. If the increase in human capital is sufficiently large such that the wage is greater than the reservation wage, the economy is no longer in phase two. If RTA intersects the MHC below the 45° line (so that $\tilde{m}_A < m_A$), all available female human capital is employed. Figure (9) illustrates the labor market equilibrium in this phase. Increased human capital and savings has shifted the demand curve for female labor up and to the right. The equilibrium wage is above $\overline{w}$ at w_A^3 and all female human capital is employed.

In phase three, the level of human capital is sufficiently high that the equilibrium wage exceeds the reservation wage. All female human capital is employed in sector A. The ratio of suppliers using the new organizational mode to all suppliers in the sector, when the economy is in phase three, is:

$$\frac{\widetilde{m}_{A,t}}{m_{A,t}} = \frac{(1-\alpha)^{\frac{1}{\alpha}} \frac{H_t^w}{H_t^m}}{\left(\frac{1}{1-\alpha}\frac{1-\nu}{\nu}\right)^{\frac{\alpha}{\alpha-\rho}} (\chi_t)^{\frac{\alpha-\rho+\alpha\rho}{\alpha-\rho}} - \alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}} \frac{H_t^w}{H_t^m}}. \tag{31}$$

Proposition 3: *There exists a χ_t^3, such that if $\chi_t^3 > \chi_0$ then i) a phase three equilibrium exists in which all human capital is employed, ii) the variety of intermediate inputs in G is growing proportionally faster than human capital (χ is increasing over time) if female human capital is growing rapidly relative to male human capital, and iii) in that equilibrium, if the growth rate of female human capital relative to male human capital is greater than the growth rate of technology adoption in administration, the proportion of suppliers that using the new organizational mode increases when human capital increases.*

Proof: See Appendix D.

As savings increases the RTA curve will shift up. The MHC curve also shifts up as the supply of female human capital increases relative to male human capital. The proportion of suppliers using the new organizational mode will increase if the curve RTA shifts up by less than MHC. Increases in the supply of skilled female workers puts downward pressure on the rate of investment into inputs in sector A, as individual inputs become more productive on average. This decreases the growth rate of m_A and increases $\tilde{m}_A$ relative to m_A.

For the given wage functions for both male and female human capital it is possible to determine the relationship between the wage in G and the wage in A in every period. Dividing the clerical wage by the production wage, the ratio of wages in every period is:

$$\frac{w_{A,t}}{w_{G,t}} = (1-\alpha)^{\frac{1}{\alpha}} \left(\frac{1}{\chi_t}\right) \tag{32}$$

As χ is increasing in phase three (Proposition 3) it must be the case that in every period the wage paid to workers in Administration is falling relative to the wage paid to workers in Goods.

5.4 Phase Four: Full Clerical Employment with No Surplus Human Capital

Figure (10) and (11) illustrate the equilibrium in phase four. As in phase three, an increase in savings has shifted both RTA and MRW up and to the right. If the growth rate of female human capital relative male human capital is such that RTA intersects the 45° line below MHC with $n = \widetilde{n}$, and, if MRW intersects the RTA above the 45° line, then the economy is in phase four and m_A is determined by the

equation

$$m_A\left(H_t^w, H_t^m, s_{t-1}\right) = \frac{\left(\frac{1-\nu}{\nu}\right)^{\frac{1}{\alpha-\rho+\alpha\rho}}}{\left(\frac{H_t^m}{H_t^w}\right)^{\frac{\alpha\rho}{\alpha-\rho+\alpha\rho}} + \left(\frac{1-\nu}{\nu}\right)^{\frac{1}{\alpha-\rho+\alpha\rho}}} \frac{1}{\gamma} s_{t-1}. \tag{RTA-4}$$

All suppliers use the new organizational mode and employ clerical workers. The wage is above the reservation wage and the number of workers per technology exceeds the level in phase three. All female human capital is employed .

The growth rate of the economy in this equilibrium is given by the definition:

$$\frac{\dot{m}_A}{m_A} = \frac{\dot{\chi}}{\chi} - \frac{\alpha\rho}{\alpha-\rho+\alpha\rho} g^W + \frac{\alpha\rho}{\alpha-\rho+\alpha\rho} g^M \tag{33}$$

and is a function of the relative growth rates of male to female human capital. If female human capital is growing relative to male human capital the level of technology adoption in A is growing slowly relative to the level of technology in G. If, over time, the growth rate of male to female human capital converge, then the growth in the technology in both sectors will also converge.

Proposition 4: *There exists a χ_t^4 such that for all $\chi_t^4 \geq \overline{\chi}_t$, a phase four equilibrium exists in which all producers use the new mode of organization.*

Proof: See Appendix E.

The demand for female labor is more elastic in phase four than in phase three. In phase three, the wage rate is a function of both the choice of mode of organization and the rate of technology adoption. An increase in the measure of suppliers using the new organizational mode increases the demand for workers, driving up the wage. However, an increase in the measure of suppliers using the new mode of organization also reduces the rate of technology adoption, reducing output in that sector and putting downward pressure on the wage. Changes in the organizational mode and the rate of technology adoption has offsetting effects on market wage. In phase four all suppliers use the new organizational mode and the wage rate is a function of the rate of technology adoption.

5.5 Transitions Through The Phases

Figure 12 illustrates the movement of the economy through the four phases. When human capital is low the economy is in phase one; no supplier finds it profitable to use the new organizational mode. Phase

one is every point along the x-axis (with $\widetilde{m}_A = 0$) up to the point at which:

$$m_A(s_{t-1}) = \frac{1}{\gamma} s_{t-1} - \overline{\chi}_t. \tag{34}$$

In phase two, suppliers pay exactly the reservation wage and some of the potential human capital remains unemployed. If the increase in savings is sufficiently large such that investment in technologies in A increases over time, the proportion of suppliers using the new organizational mode is increasing in human capital. If this is not the case, and investment in sector A is decreasing, the proportion of suppliers using the new organizational mode in sector A will increase. The demand for female workers is growing in phase two.

In phase three, all female human capital is employed in the clerical work force. Individual suppliers are constrained only by the level of labor input they can employ. Both the growth rate of technology adoption and the transition to the new organizational mode is a function of the relative growth rates of male to female human capital. If female human capital is growing slowly relative to male human capital, the level of technology adoption will be rapid but the proportion of suppliers using the new technology will fall over time (M_A increases but the ratio of $\widetilde{m}_A$ to m_A falls). If female human capital is growing rapidly, relative to male human capital, the proportion of suppliers using the new technology will grow over time but the technology in the sector will be falling (M_A decreases and the ratio of $\widetilde{m}_A$ to m_A increases). For a moderate growth rate in female human capital, relative to male human capital, both technology and the proportion of suppliers using the new mode is increasing over time (M_A and the ratio of $\widetilde{m}_A$ to m_A increase). If this is not the case, and the proportion of suppliers using the new mode is falling over time, the economy will stay in phase three despite increases in the skill level of the population. If the growth rates of male and female human capital are converging to a common growth rate, it may be the case that an initial increase in the proportion of suppliers using the new mode is followed by rapid technology growth and a falling proportion of suppliers using the new mode as the growth rate of female human capital slows relative to that of male human capital.

If phase four is reached, all suppliers have chosen to use the new organizational mode. In this phase, the supply of skilled workers is sufficiently high that suppliers can increase their labor input above the

initial constrained level. If the labor input per technology is growing, as human capital increases, the level of technology adoption will slow in that sector. Given that Goods and Administration are compliments, a sufficiently large increase in labor input in sector A, which increases the level of output per technology, will decrease the level of investment in technologies in that sector. If, over time, male and female human capital growth rates converge, the growth rates of investment in the two sectors will converge as well.

Note that if the increase in output per technology in sector A is sufficient to offset increases in technology adoption, then either the adoption of the new organization mode (in phase three) or the increase in labor input per technology (in phase four) is fueling an increase in technology adoption in the manufacturing sector relative to the administration sector.

5.6 Simulation Results[16]

To further demonstrate the dynamics of the model, a simple simulation is presented in which human capital grows exogenously over time and economic rents determine both the organizational structure and the relative rate of technology adoption between manufacturing and administration. The model is simulated over 20 periods. For the first 16 periods female human capital is growing fast relative to male human capital and in the final four periods is growing at the same rate as male human capital (see Figure (13)). The key parameters are $\alpha = 0.6, \rho = -1$, $\nu = 0.85$ and $\tilde{n} = 4.6$. The reservation wage is set such that the economy is in phase one at the beginning of the simulation. In each of the figures, the phase in which the economy is in is labeled on the top axis. Figure (14) plots the natural logarithm of investment in administration and the relative rate of technology adoption in Administration to Goods. Figure (15) plots the share of A produced by suppliers using the new technology and the share of intermediate output that is Administrative output is in Figure (16). Clerical workers wages are illustrated in Figure (17) (absolute and relative levels) and Figure (18) (share of the total wage bill).

In Phase One, as the level of male human capital employed in sector G increases the corresponding increase in total output in that sector puts downward pressure on profits while simultaneously increasing savings. As none of the increase in female human capital flows into production, as no supplier in A finds

[16]The algorithm used to simulate the model is available from the author upon request.

it profitable to chose the mode of organization that employes skilled workers, technology in A increases in absolute terms (due to the complementarity of inputs) but decreases relative to technology in G (Figure (14)). As predicted in Proposition One, the increase in male human capital is sufficient to drive up the wage firms would be willing to pay female workers over time (see Figure(17)) and the economy moves into Phase Two in the third period. In Phase Two and throughout most of Phase Three, investment in A increases slowly, both in absolute terms and relative to G. The growth rate of female human capital relative to male human capital is such that the share of technologies adopting the new mode is growing rapidly over time (see Figure(15)). As these technologies produce significantly more output than technologies using the old mode, total output in that sector increases rapidly putting downward pressure on relative profits; investment in A falls relative to G. Despite this fall in relative investment, the share of all intermediate output that is produced by that sector increases rapidly in Phase three (Figure (16)). Additionally, despite the increase in the supply of skilled workers and the fall in investment in that sector, the wages of these workers increases over time, as does the share of the total wage bill paid to clerical workers (Figure (18)). As predicted by the model, the relative wage of these workers falls in Phase Three. In Phase Four all producers in A use the new mode, investment in that sector increases and, as the growth rate of female human capital converges to that of male human capital, the growth rate of investment in both sectors converges.

6 Conclusions

This paper presents a dynamic general equilibrium model which relates the increase in female labor force participation to three, critical, changes in the economy: increased skill levels of the population; increased division of labor in administration; and the rapid adoption of new technologies. By explicitly modelling the dynamics of the economy as it moves from one in which skilled workers are scarce to one in which they are relatively abundant in a framework that allows for organizational change, we observe some surprising results. The standard induced technological change model predicts that is that investment will flow to a technology that complements a factor of production whose relative price is falling. A model with

organizational technology as well as technology that is embodied in physical capital, however, will, in some instances at least, predict the opposite; investment will flow away from technologies that complement the factor of production that is growing in abundance if firms are reorganizing to incorporate these workers into the production process in such a way that increases output per unit of technology. Despite this fall investment the relative price of the factor will be driven up over time as firms reorganize to incorporate the factor into production. We find that the increasing skill level of all workers is sufficient to generate a restructuring of firms to incorporate skilled, female workers into production and that over time the share of the wage bill paid to clerical workers will increase up to the point at which the growth rate of female human capital converges to that of male human capital.

There is no doubt that a variety of factors played a role in the remarkable transformation (in both the composition and size) of the American workforce. Models of female labor force participation which focus exclusively on factors that pushed women out of the home, however, fail to properly account for the impact of the early restructuring of the workplace; a reorganization which set the stage for the extraordinary expansion of the household labor supply that followed the second world war and continued for much of the twentieth century.

7 Definition of Variables used in the model

c	Consumption of market produced goods and services
h	Consumption of household produced goods and services
I	Total household income
S	Savings
Y	Final good output
A	Administration output
O	Goods output
x_A	Output of a supplier in administration sector
x_G	Output of a supplier in goods sector
n	labor input to a supplier in administration
l	labor input to a supplier in goods
m_A	Measure of technology/suppliers in administration
m_G	Measure of technology/suppliers in goods
$\widetilde{m}_A$	Measure of technology/suppliers in administration using new mode
H^m	Male human capital
H^w	Female human capital
L_u	Stock of unskilled workers (for men (L_u^m) and women (L_u^w))
L_s	Stock of skilled workers (for men (L_s^m) and women (L_s^w))
$\overline{w}$	Reservation wage

All lower case technology variables are deflated by the level of male human capital.

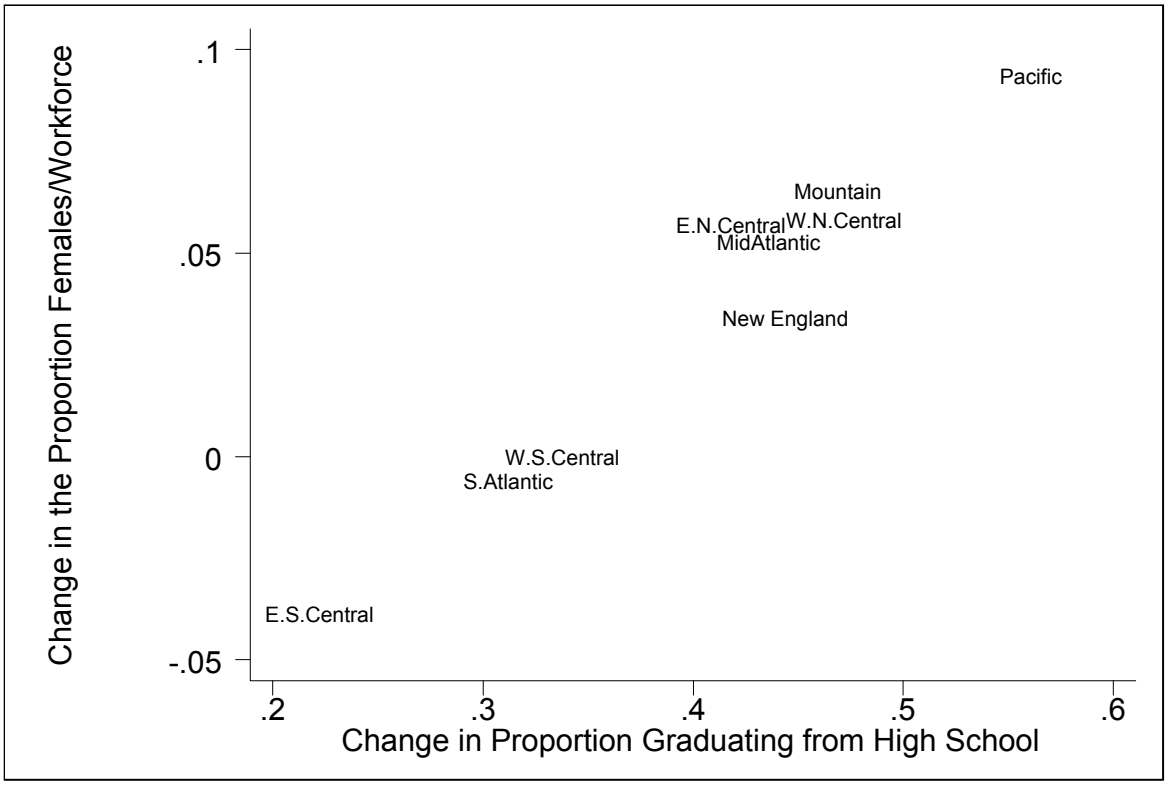

Figure 1: Changes in high school graduation rates and the female labour force over nine census regions. The change in the proportion of high school graduates is the difference between the high school graduation rate in 1910 and 1940 (from Goldin, 1994). The change in the proportion of female workers is the difference in the percentage of workers who were women between 1910 and 1940 (from *Historical Statistics*).

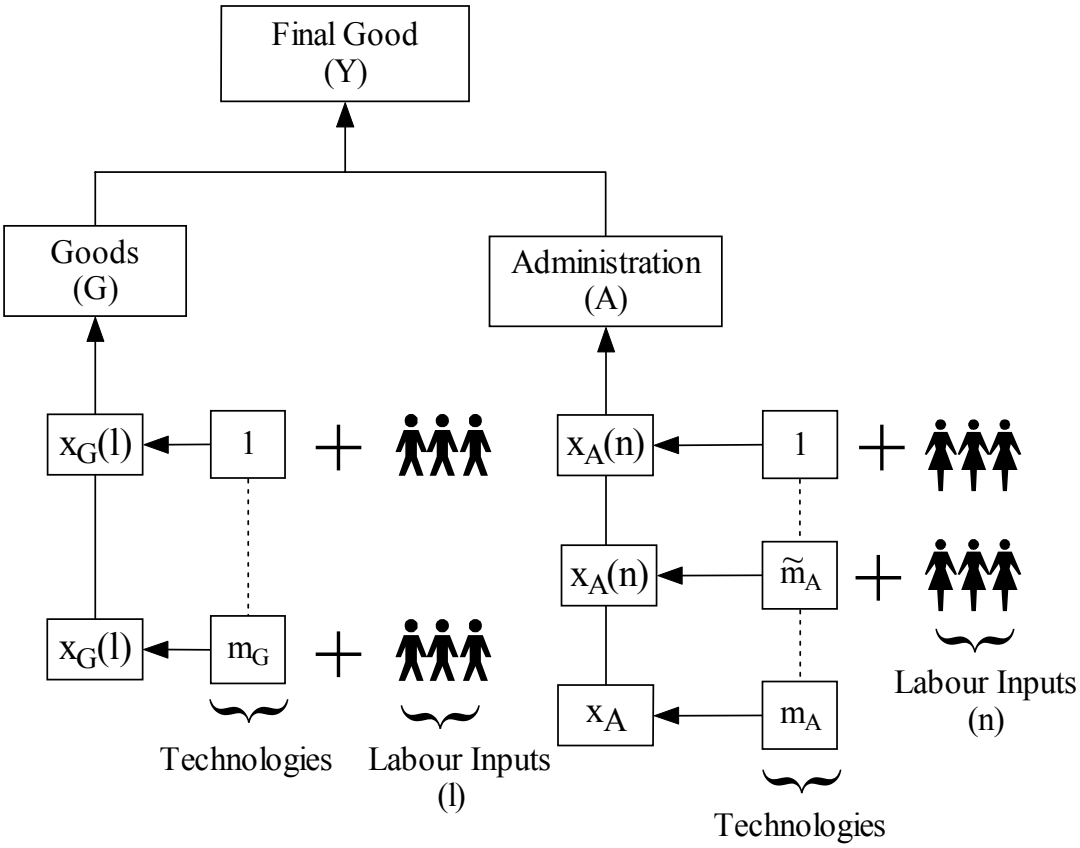

Figure 2: The organizational Structure of the Firm

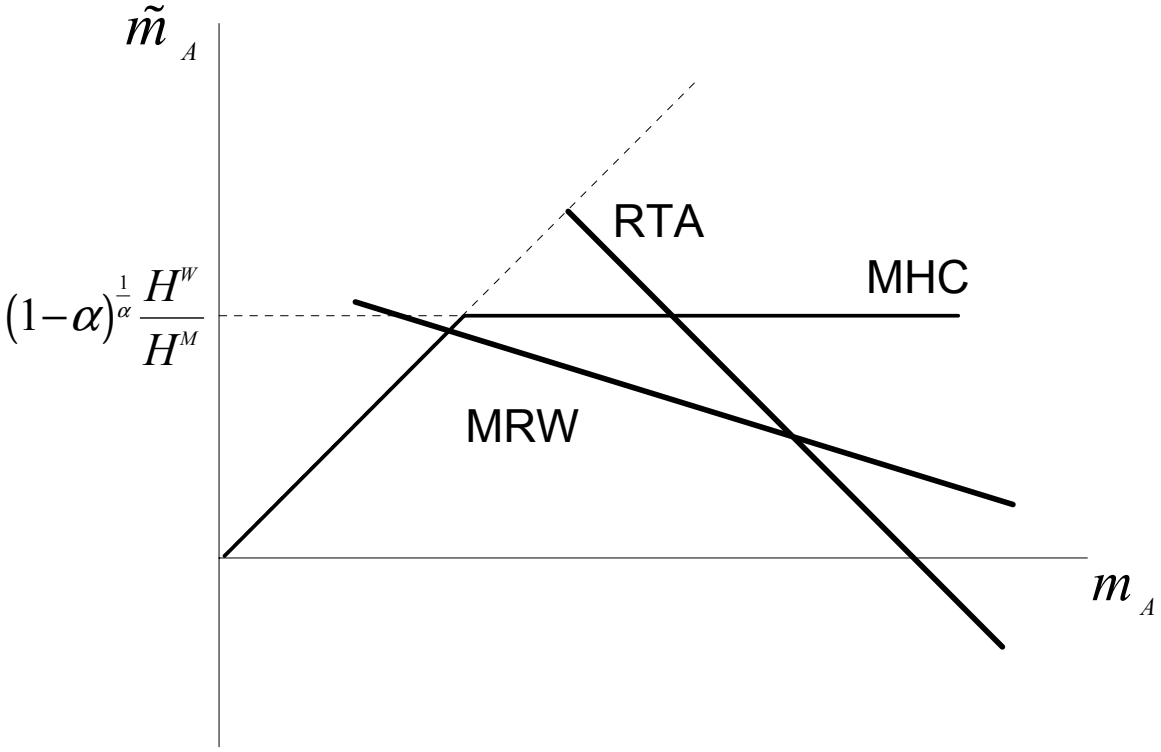

Figure 3: Illustration of an Equilibrium with RTA, MHC. and MRW

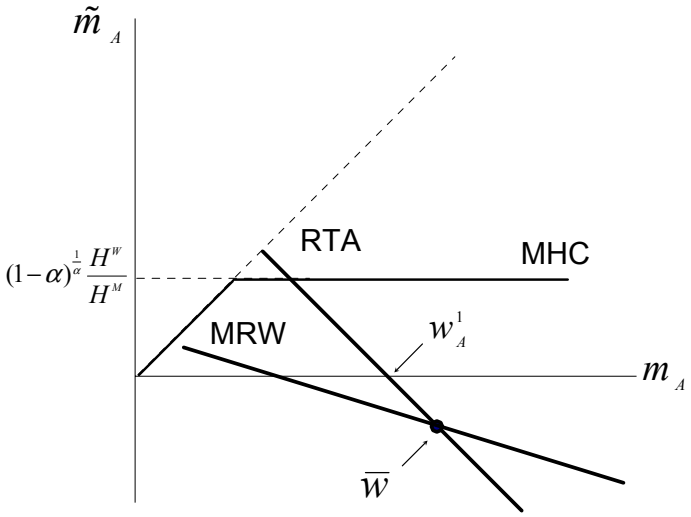

Figure 4: A Phase One Equilibrium

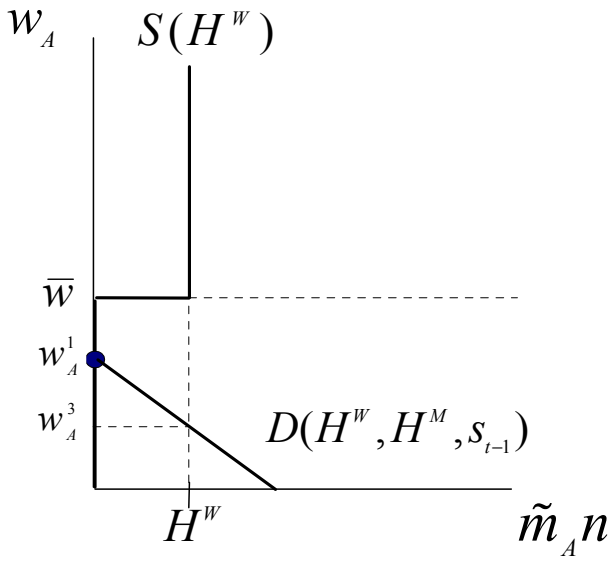

Figure 5: Labour Demand in a Phase One Equilibrium.

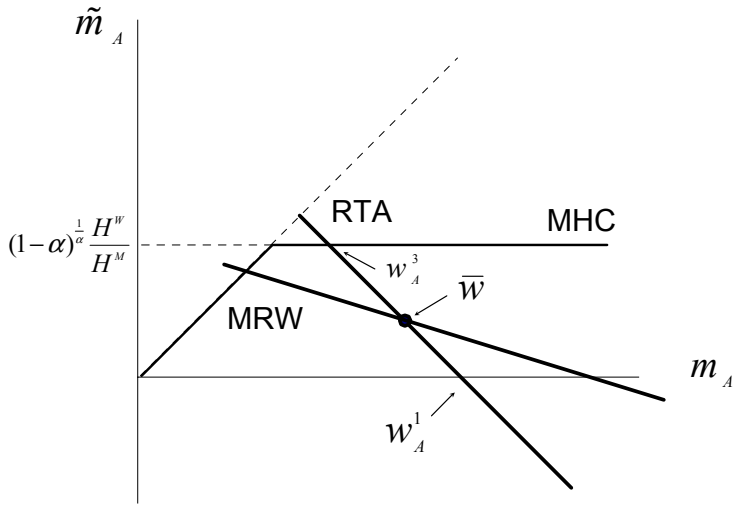

Figure 6: A Phase Two Equilibrium

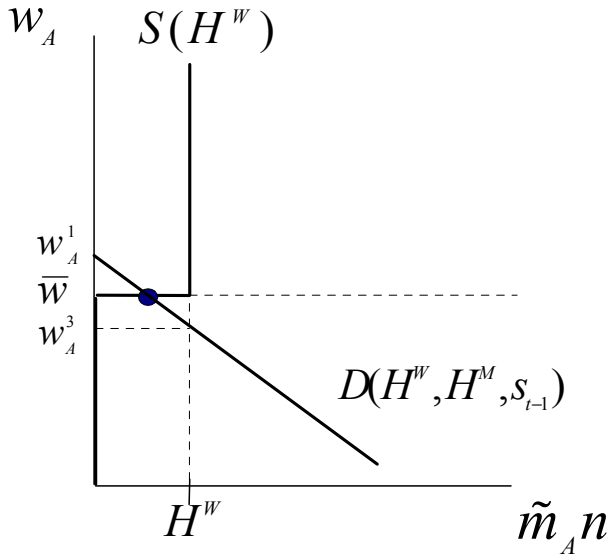

Figure 7: Labour Demand in a Phase Two Equilibrium

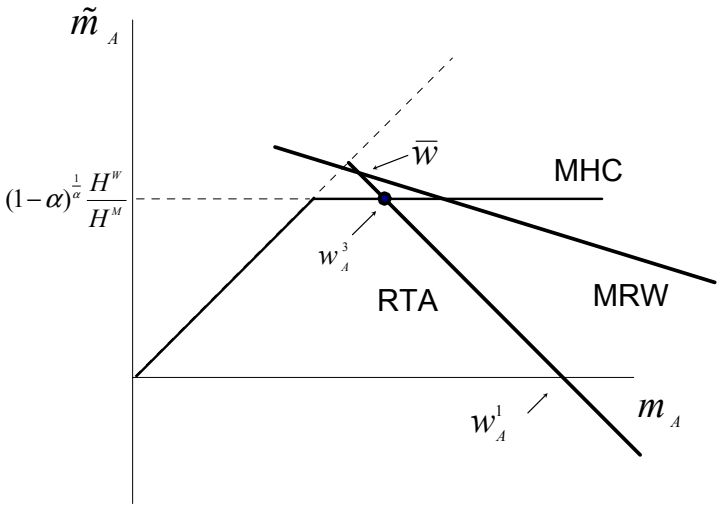

Figure 8: A Phase Three Equilibrium

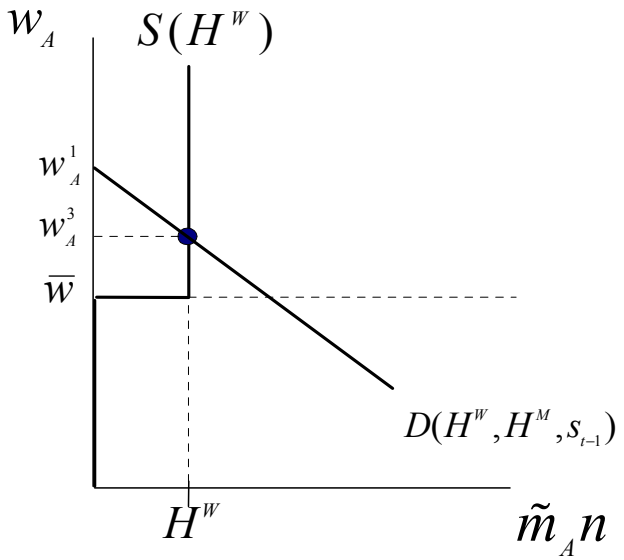

Figure 9: Labour Demand in a Phase Three Equilibrium

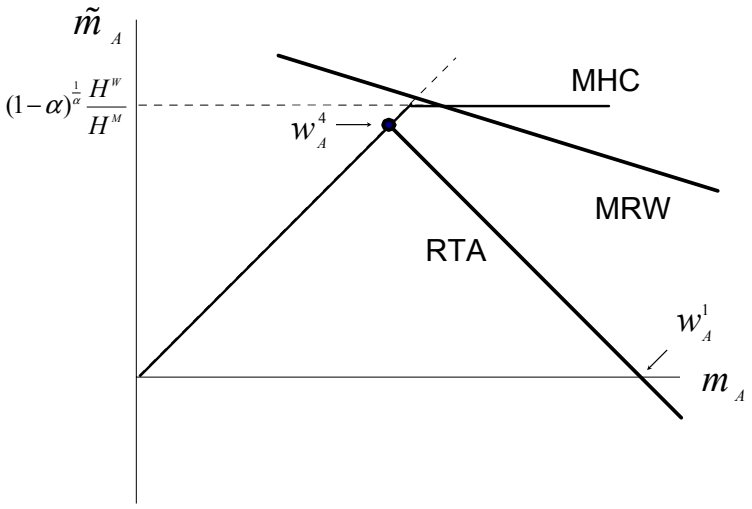

Figure 10: A Phase Four Equilibrium

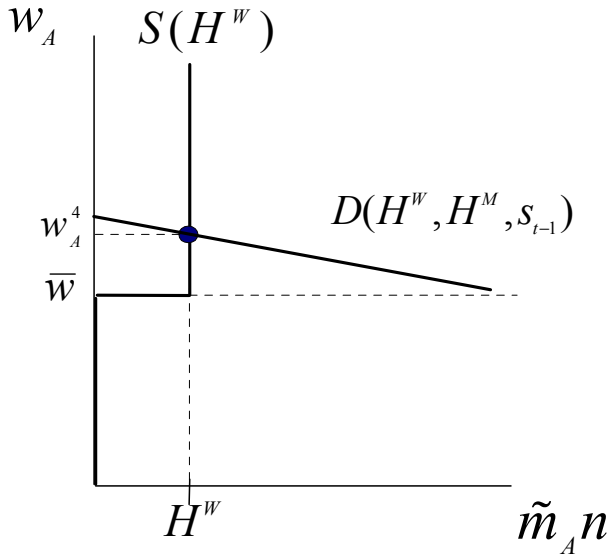

Figure 11: Labour Demand in a Phase Four Equilibrium

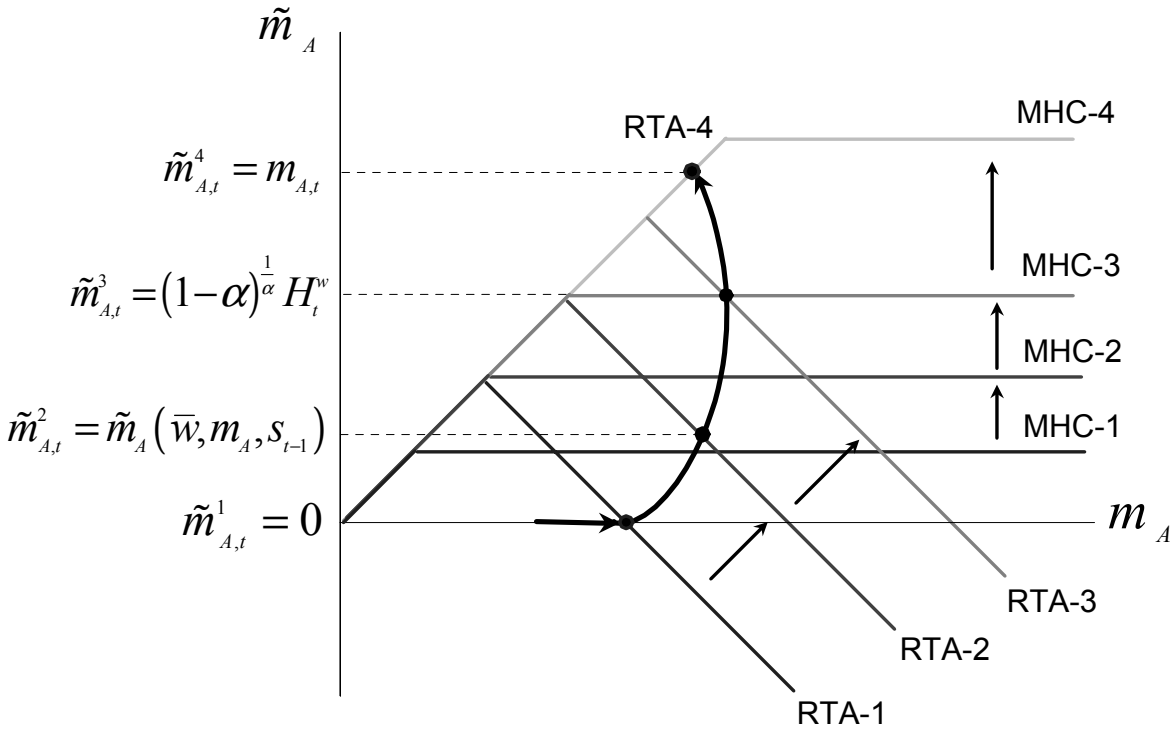

Figure 12: Transitions Through the Phases

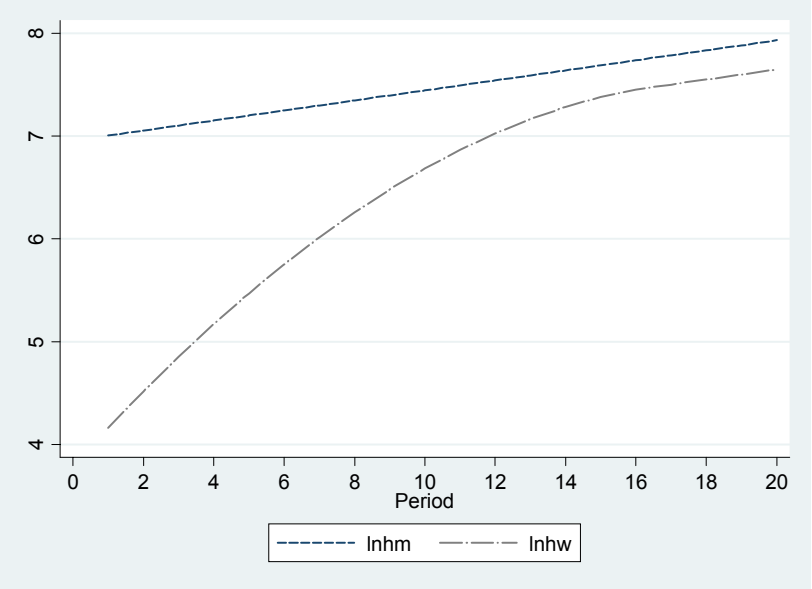

Figure 13:

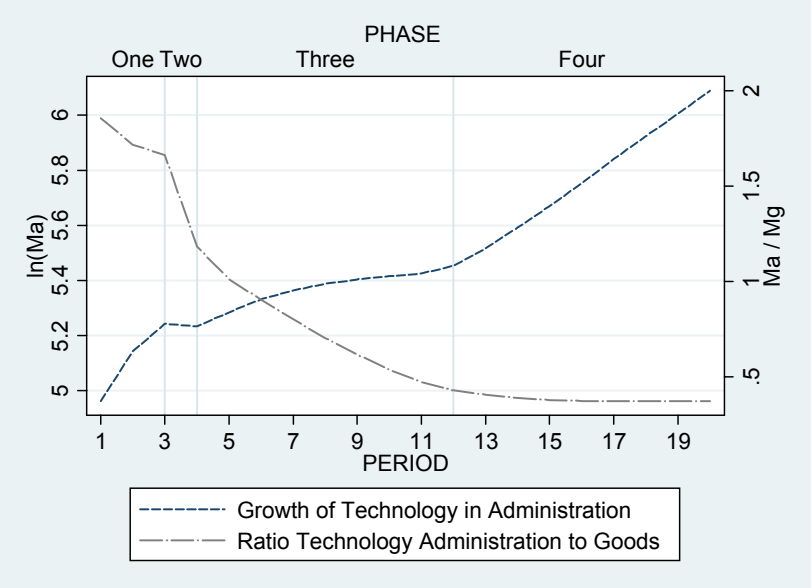

Figure 14:

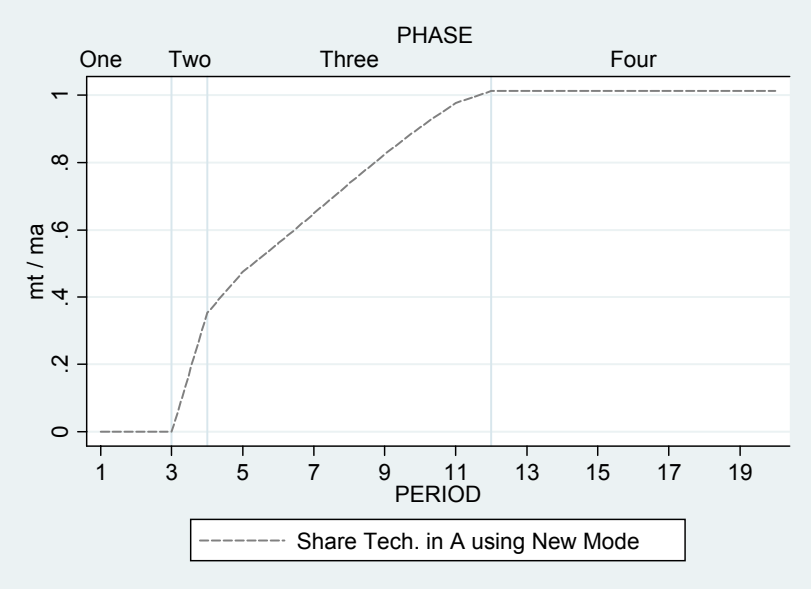

Figure 15:

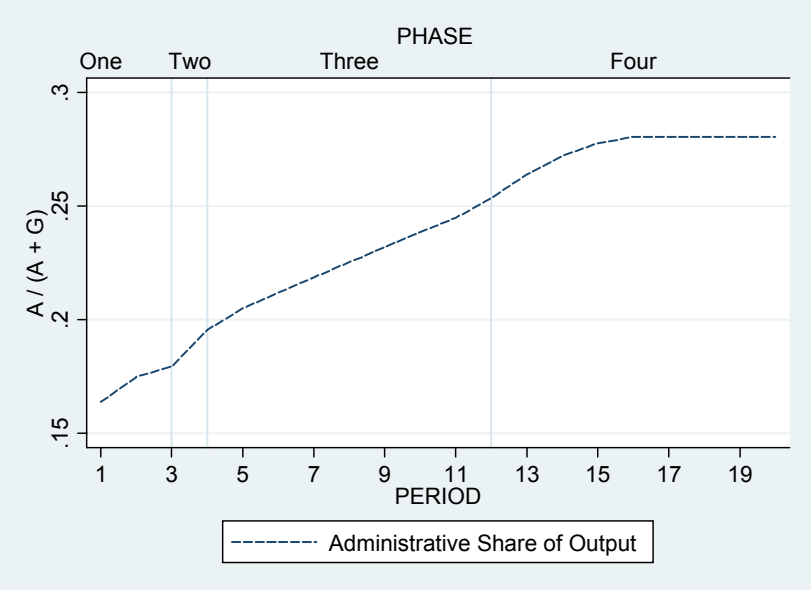

Figure 16:

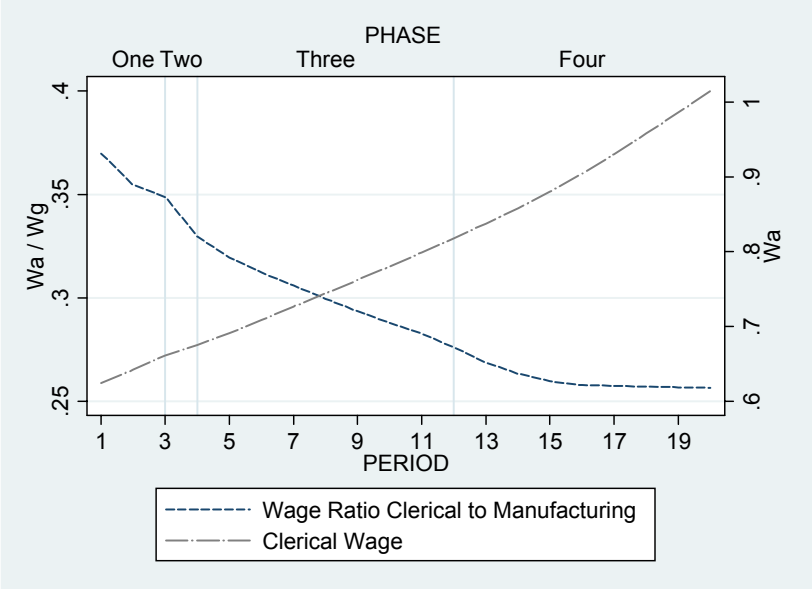

Figure 17:

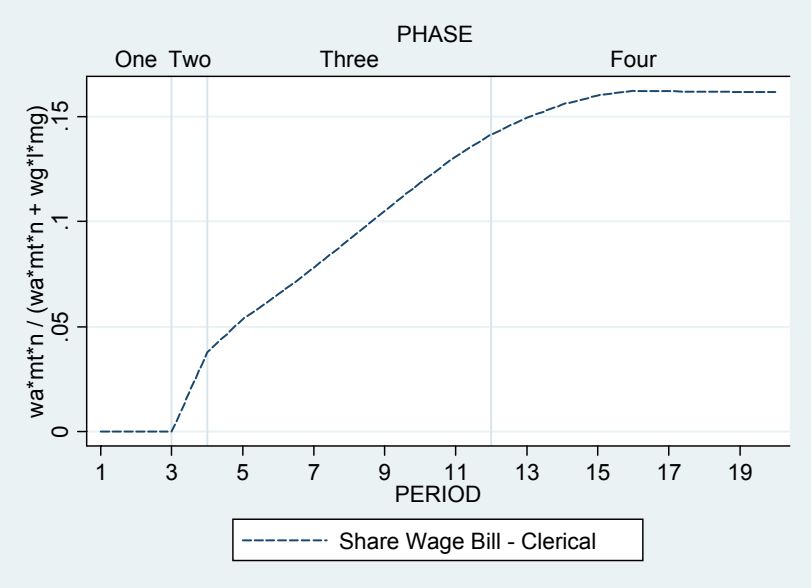

Figure 18:

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