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The Impact of Wage and Labour Flexibility on Employers and Employees

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Abstract labour market flexibility, working time arrangements and work-life balance are important issues on the political agenda of many societies. The present paper captures the trade-off between the interests of employers and employees by adjusting working hours to the employee availability constraints. A theoretical model is developed in order to determine the ideal wage gap between full-time and part-time employees. The paper proposes a method of computing a "fair" wage rate for part-time employees that is driven by purely financial considerations which ensure that neither employers nor employees are penalized by the employment arrangement. The ideal wage that is identified can serve as a benchmark for a "justifiable" wage gap (also referred to as "wage differences") between part-time and full-time employees. Policymakers can rely upon the method presented for computing a "fair" wage rate for part-time employees. Another dimension of labour flexibility in the field of Human Resource Management is discussed in order to define an appropriate wage gap between part-time and full-time employees.

Keywords: *wage difference, wage discrimination, employment cost, work productivity, quasi-fixed labour costs*

JEL Classification: D24; J2; J3; J7

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1. Introduction

In recent decades, labour market flexibility has been an important issue on the public agenda, as it holds the potential to increase the competitiveness and effectiveness of the labour market in a rapidly changing social and economic environment [1,2].

Labour market flexibility is an abstract and potentially confusing concept [3,4], with multiple definitions among different researchers and disciplines. These definitions include the following: (i) the adjustment of employment, working time and wages to economic changes [5]; (ii) the allocation of resources in a Pareto-efficient way [6,7]; and the adaption of the labour market to changes in society, economy and production [4].

According to Chung, Kerkhofs, and Ester (2007) ([1], p.5), the most widely used definition of labour market flexibility includes the following four categories:

(i) "External numerical flexibility refers to the adjustment of the labour intake or, in other words, to the number of workers employed from the external market outside the company."

(ii) "Internal numerical flexibility is sometimes known as working time flexibility or temporal flexibility. It is achieved by adjusting working hours or schedules of workers already employed within the organization."

(iii) "Functional flexibility or organisational flexibility is the extent to which employees can be transferred to different activities and tasks within the company."

(iv) "Financial or wage flexibility exists where wage levels are not decided collectively and greater differences emerge between workers' wages."

Labour market flexibility increases the ability of companies to adapt to changes in external and internal circumstances. Such changes might include external shifts in labour supply dynamics or changes in demand for a company's products [8].

This study investigates the ways in which an employer can implement financial flexibility in conjunction with internal numerical flexibility. It takes into account the personal constraints that determine the supply of labour by employees as well as the labour requirements of the employer.

Financial or wage flexibility might include differences between the hourly wages of part-time employees and those of full-time employees [1].

Many labour markets today are required to enable individuals to adjust their working hours to their particular dynamic needs (e.g., education, childcare, a spouse's sabbatical, etc.).

Various studies on working time flexibility focus on the employer's perspective rather than that of the employee, (with some exceptions, e.g., [9,10]). For example, they investigate how flexibility can enable firms to fulfil production requirements. The working time flexibility literature (e.g., [11-17]) includes studies on the preferred distribution of hours among employees and the strategy for integrating people into the market. As Chung [2] explains, "Working time flexibility can be used as a strategy to integrate more people into the market, prevent unemployment, and decrease polarization of the market" (p. 10). Other studies discuss the issues regarding the preferences of employees with respect to daily working hours [18,19,20].

The literature also includes studies that examine the implications of adopting various working time flexibility arrangements (e.g., [21,22]). Others investigate working time arrangements as part of a broader company policy of employee work-life balance [23,24,25,26].

A key issue examined in the Human Resource Management (HRM) literature is the extent to which it contributes to organizational effectiveness [27]. It has been argued (e.g.[28,29]) that success in today's highly competitive markets is less a function of the company's economies of scale, advanced technology, inventions, and ability to raise capital; and more a function of the innovation, pace, and adaptability that the company's human resources provide. As such, flexibility in the workplace with respect to the number of daily working hours, the use of part-time jobs, the starting time for work etc., may prove to have far-reaching implications for HRM [30,31,32].

The spate of developments in the economic, political, technological and social spheres during recent years has caused significant changes in the composition of the labour force as well as in the types of labour that companies are currently seeking. In order to fully comprehend the challenges with which HRM must successfully grapple in the coming years, one must understand the labour market context of the workplace.

As markets become more dynamic and hence less predictable, corporate managers of human resources must respond appropriately by increasing the flexibility both of their organizational and labour force structures to enable more efficient implementation of human resources.

Changes in organizational structure significantly affect employees with respect to job content, employee motivation, job security, and organizational commitment, especially since employers have often used the pretext of "flexibility" in reorganization in order to justify redundancies [33].

One major determinant of an organization's ability to respond effectively to the changes and uncertainty of the business environment is the composition of its workforce, which must be flexible and adaptable. Flexible, adaptable business processes are able to respond rapidly to changing circumstances such as fluctuations in consumer demand, which call for flexibility of the individual and collective employee alike. The flexibility of the labour market is defined by an employer's ability to hire employees or terminate their employment as needed, fix wages according to market needs, allocate manpower efficiently within the company, and change working hours to suit the needs of the company [34].

While the ultimate objective of flexible labour systems is to minimize labour costs [35], employers contend that flexible working practices may be introduced for a variety of reasons, from improving organizational performance to responding to the personal needs of employees.

A key tenet of many HRM "best practice" models (for example, High Performance Work Systems) is increasing flexibility by allowing employees to master many skills. This can be beneficial both to the employees (in improved job satisfaction due to variety and challenge at work) and to the employer (in enhanced functioning of the individual and the organization as a whole).

HRM seeks out new working arrangements as a way of improving labour efficiency [36,37]. Developing the employee's time more effectively is an obvious measure that leads to increased productivity [10,38,39].

Part-time work is an employment arrangement in which the employee works for fewer than the company's usual full-time hours. In companies that use a typical 40-hour work week, individuals are commonly considered to work part-time if they work fewer than 35 hours per week.

Part-time work is one of the most common manifestations of working time flexibility. In certain cases companies introduce part-time work in order to meet economic needs, attain certain cost benefits, and increase flexibility, although sometimes to the detriment of employees.

Many women elect to work part-time in an effort to reconcile work and family life, as women are still more likely than men to take on family caregiving for children or elderly family members. In the economic literature [40] there are two main opposing views on the efficiency of part-time work for women. The negative view is that part-time employment leads to "wastage of resources and underutilization of investments in human capital" ([40], p. 263), since many highly-educated women who work part-time do not fully utilize their skills, experience and qualifications. The positive view is that in the absence of the option to work part-time, female participation in the labour force would be "substantially lower, since women confronted with the choice between a full-time job and zero working hours would opt for the latter" ([40], p. 263).

At the firm level, a common motivation for introducing part-time employment is to increase productivity. Employers might believe that by enabling employees to achieve a better balance between their work and personal lives, they can increase employee satisfaction and raise overall productivity, as well as enhance their own reputations [41,41,42,43].

Yet there are multiple factors that suggest that introduction of part-time employment might not be in an employer's best interests since part-time employees have been shown to be less productive than full-time employees [44,45,46,47,48,49]. Nelen, De Grip, and Fouarge [50] find that due to greater part-time employment, the productivity of a firm and the efficiency of its labour allocation increase. Part-time employees can substitute full-time employees so that they can take lunch breaks while the firm remains open. Part-time employment can reduce idle time and increase opening hours, enabling a

full-time work week. Part-time employees can bridge the working hours and the fluctuations in customer demand between peak and regular hours in the case of restaurants, services, etc.

Personal and job characteristics partially explain the difference between the hourly wages of part-time and full-time employees. Indeed, on average, part-time employees are more likely to have less education and to work for small firms that offer less training or fewer promotion opportunities. Estimates find that personal characteristics usually explain only a small part of the part-time wage penalty. Job characteristics are of much greater importance, including occupation for women, and industry and contract type for men. However, while occupation and sector segregation may be attributed to personal preference that justifies wage differences, it may also conceal direct wage discrimination by employers [51].

Garnero [51] presents the advantages and disadvantages of part-time employment. Among the advantages, she indicates the flexibility for employers and employees. Employees benefit from less stress and a reduced health risk, while employers can adapt employment to fluctuations in demand. According to Garnero [51], part-time work has contributed to higher employment rates for women in many countries. On the other hand, included among the disadvantages, she finds the correlation between part-time employees and their underpaid salaries that moreover may even generate discriminatory wage reduction. At the same time, part-time employees have fewer career opportunities. Another disadvantage is that the employment of part-time employees is more expensive and therefore the employer might not want to invest in their promotion and skills.

Theory may suggest that the productivity of part-time employees might be higher than that of full-time employees for different reasons, including among them less stress, less absenteeism, a better work-life balance, and a more flexible workplace. In addition, productivity could be higher for part-time employees, who are required to accomplish full-time work in a shorter time. This could result in a discriminatory gap between productivity and wages of part-time employees. Moreover, hiring part-time employees might enable firms to increase productivity by extending opening hours or better utilizing capital. Thus flexible working hours might result in both increased productivity and higher wages for part-time employees. In contrast, productivity may be lower with respect to involuntary or short-term, part-time work since individuals may be less engaged in their work. Lower productivity may result from less investment in training when part-time employees that are less committed to career goals may choose to forgo training opportunities. Employers may also be less inclined to invest in training part-time employees since the return would be lower than for full-time employees [51].

Lewis (2003) [52], examines flexible working arrangements and productivity differences between full-time and part-time employees. Part-time employees generally cost more to the workplace so that their wages may be lower. It has also been argued that part-time employment creates coordination problems, particularly when there are few part-time employees in comparison with full-time employees.

However, part-time employees may perform full-time jobs within somewhat less time. This interpretation is supported by the literature arguing that for various reasons, many part-time employees continue to be assigned full-time workloads.

An important aspect of flexibility in the HRM literature is the issue of part-time as compared with full-time jobs. In order for companies to effectively manage organizational change and successfully adapt to competitive markets, they must strive for flexibility [53].

Theoretically, no definite relationship is found between part-time employment and productivity. Human capital theory predicts decreased productivity for part-time employees in comparison with full-time employees because of the lower remuneration the employers receive for their human capital investments. Studies conducted on the wage penalty for part-time employment indicate that this is indeed the case (e.g. [47,48]). In contrast, several studies examining the demand for part-time labour suggest that companies may benefit from hiring part-time employees when operating hours exceed the regular working week or when companies encounter fluctuations in customer demand over the working day or week [41,42]. Service sector companies are those most likely to benefit from the potential benefits of part-time employment.

Labour market flexibility and in particular the implementation of flexible working hours and part-time employment opportunities, combined with differences in wages among employees who are hired under different terms, can serve the interests of both employers and employees. Specifically, such flexibility at the firm level both enhances the ability of employers to respond to changes in external and internal conditions and enables employees to adapt their employment arrangements (i.e. their working hours) to their changing needs. Many employees prefer flexible employment arrangements because these suit a specific lifestyle or personal status, e.g., married, single, single parent, etc. Mothers, for example, are more likely than other groups to provide childcare, for which they are not paid. This responsibility potentially limits the number of hours they can work outside the home and, correspondingly, their earnings. This is particularly true for single mothers, who not only serve as primary breadwinners but also bear sole responsibility for the well-being of their children. Beneria [54] refers to this issue, suggesting that societies should find ways to compensate caregivers for their roles. However, in the meantime many mothers are able to achieve both goals only if they are offered flexible working hours. Thus, labour market flexibility has played a role in increasing female participation in the workforce, especially among single mothers. Flexible working hours also appeal to students who spend long periods of time studying and must schedule their working hours around their study obligations.

This article analyzes and describes the trade-off between the interests of employers and employees regarding flexible labour practices. The employer is restricted by the family and social needs of employees and incurs the additional expenses attendant upon employing part-time employees. To offset this constraint, employers pay lower wages to part-time employees than to full-time employees,

an economically justifiable wage difference that is not defined as wage discrimination. The quasi-fixed cost increase due to hiring more part-time employees to compensate for hiring fewer full-time employees requires partial reduction in part-time employee wages in comparison to those of full-time employees.

This research investigates how employers address the need for more flexibility in the workplace. This requires greater flexibility in the number of hours that employees are obligated to work, i.e., availability of part-time employment opportunities. The study assumes that when an employer offers working time flexibility, he or she might compensate for it by paying part-time employees lower wages as compared with full-time employees. The research develops a model for determining the optimal wage difference between full-time and part-time employees (from the employer's perspective). The model takes into account constraints on the supply of labour which are influenced, for example, by the demands of the private lives of employees, as well as by the employer's requirements and the costs associated with hiring and employing employees for fewer daily working hours or on a part-time basis. The present model excludes the possibilities that either the flexibility of part-time employment generates job insecurity, or that productivity is lower for a part-time employee. However, employees only gain advantages from flexibility. The benefits that an employer gains from offering part-time positions, or that an employee gains from working part-time, are "balanced" by costs to each of the parties. This may generate a trade-off between job flexibility in daily working hours, and wage differences intended to compensate employers for the costs imposed by job flexibility. The current paper seeks to explore this trade-off. In an environment in which Pareto improvement exists, part-time employment allows the employee greater flexibility. At the same time, the result is favourable from the employer's perspective since the additional costs of employing a part-time employee are offset by a lower hourly wage.

This research develops a model that captures the trade-off between the constraints on the labour supply that is provided by employees and the requirements of and costs incurred by employers, in order to determine the optimal wage gap between full-time and part-time employees. This wage gap should compensate the employer for the quasi-fixed costs associated with employing employees.

2. Materials and Methods

2.1. The Model Assumptions Are

- Completely inelastic labour supply - Some people have to work part-time because they have to care for their children.
- The model setting illustrates a firm that faces competition in the labour market and has to take prices as given.
- The employer has no monopsony power to impose wages on the employee. The policymaker determines wage policy that on one hand addresses the employee requirements for flexibility while on the other hand does not harm the employer. This policy promotes improvements in social welfare.
- There are no differences in productivity between part-time employees and full-time employees. There is no difference in the work they are given. In other words, the productivity of eight hours per employee is exactly the same as four hours for two employees.
- There is a cost of employing an employee regardless of whether the employment is full-time or part-time.
- The employment costs of the employer for hiring two part-time employees for four hours are higher than the costs for one full-time employee for eight hours.
- The present paper does not specifically consider that a firm might employ both full and part-time employees. Furthermore, another interesting aspect of part-time work might be the shifting of tasks and responsibilities.

2.2. Supply of Hours of Labour for Each Employee

The analysis of the supply of labour begins by using a simple leisure income model and considering a representative employee, characterized by a Cobb-Douglas utility function that is affected positively by three variables with a simple time constraint:

$$U = C^{\propto} l^{\beta} n \tag{1}$$

Where C measures monetary expenditures ($) on private consumption, n is a measure of the employee's personal characteristics (of family size or status), represented here by the number of children, and l represents the number of daily hours available for leisure.

The time vs. income constraint is:

$$C = W\left(\overline{T} - l - t_n \cdot n\right) + V + T_r \tag{2}$$

Where t_n the average number of hours per day is devoted to caring for one child; thus, $t_n \cdot n$ is the total time the employee devotes per day to childcare; V is the employee's income that is not from work; T_r is a transfer payment, and W is net hourly income. $\overline{T}$ is the total number of available daily hours that can be devoted either to childcare, leisure, or work (generating income).

Theoretically, subject to budget constraints, an employee can determine how many hours to work, how much to consume, and his or her optimal number of children, where the two latter terms are associated with time expenditures (working time required to earn funds for consumption and time devoted to childcare). However, in many cases individuals cannot exercise control over the number of children they have (e.g., for religious or biological reasons), or the extent to which they have other personal obligations. Therefore, we assume that n is not a decision variable but is given.

Thus, given the value of n, the individual decides how much time to allocate to working (i.e., the optimal

consumption level) and leisure. These decisions depend on the values of α, β and the budget constraint included in equation (2) above. The maximum of the objective function (1) subject to the budget constraint in (2) leads to the first-order condition (F.O.C) for the Cobb-Douglas utility function:

$$\frac{U_l}{U_c} = W \tag{3}$$

and

$$\frac{\beta}{\alpha}\cdot\frac{C}{l} = \mathrm{W} \tag{4}$$

From equation (4) we get $C = \frac{\alpha}{\beta}\cdot l \cdot \mathrm{W}$ Substituting this result in equation (2) yields:

$$W\left(\bar{T} - l - t_n \cdot n\right) + V + T_r = \frac{\alpha}{\beta}\cdot l \cdot W \tag{5}$$

Equation (5) can be written as equation (5')

$$l = \frac{\beta}{\alpha+\beta}\left(\bar{T} - t_n \cdot n + \frac{V}{W} + \frac{T_r}{W}\right) \tag{5'}$$

which is the demand function for leisure. Correspondingly, the labour supply of each employee is the complementary function:

$$\begin{aligned} h &= \bar{T} - l - t_n \cdot n \\ &= \frac{\alpha}{(\alpha+\beta)}\bar{T} + \frac{\beta}{(\alpha+\beta)}\left(t_n \cdot n - \frac{V}{W} - \frac{T_r}{W}\right) - t_n \cdot n \end{aligned} \tag{6}$$

Or

$$\begin{aligned} h = {} & \frac{\alpha}{(\alpha+\beta)}\bar{T} - \frac{\alpha}{(\alpha+\beta)}t_n \cdot n \\ & - \frac{\beta}{(\alpha+\beta)}\cdot\frac{V}{W} - \frac{\beta}{(\alpha+\beta)}\cdot\frac{T_r}{W} \end{aligned} \tag{6'}$$

From equation (6') we can obtain the negative effects of the number of children on the quantity of labour supplied as well as the same-direction effects of transfer payments and other sources of income. Equation (6') indicates a minimum wage rate, W_M, below which the employee will not want to work:

$$W_M = \frac{V + T_r}{\frac{\alpha}{\beta}(\bar{T} - t_n \cdot n)}$$

The effect of several parameters on the minimum wage rate W_M is:

$$\frac{\partial W_M}{\partial V} > 0 \quad \frac{\partial W_M}{\partial T_r} > 0 \quad \frac{\partial W_M}{\partial \beta} > 0 \quad \frac{\partial W_M}{\partial \alpha} < 0 \quad \frac{\partial W_M}{\partial n} > 0$$

From equation (6') we can observe that when W increases, the willingness to supply more working hours increases as well. However, there is a maximum quantity of daily labour supply, $\hat{h}$ which indicates that there is a maximum quantity of leisure time the employee is willing to give up, and that this quantity is not influenced by the wage rate. In our case we find that when $W \to \infty$, $\hat{h}$ can be computed as follows:

$$\hat{h} = \left(\frac{\alpha}{\alpha+\beta}\right)\left[\bar{T} - t_n \cdot n\right] \tag{7}$$

The right bracket indicates that $\hat{h}$ is lower for higher values of n (greater numbers of children in the employee's family).

The results are illustrated in Figure 1, below, where W indicates the net hourly wage. $\tilde{W}_M$ is the minimum wage rate at which an employee is not willing to work at all when the employee has no children (n=0) and h_0 is the maximum daily labour supply. $\bar{W}_M$ and $\bar{h}$ are similar values when the employee has children $(n > 0)$.

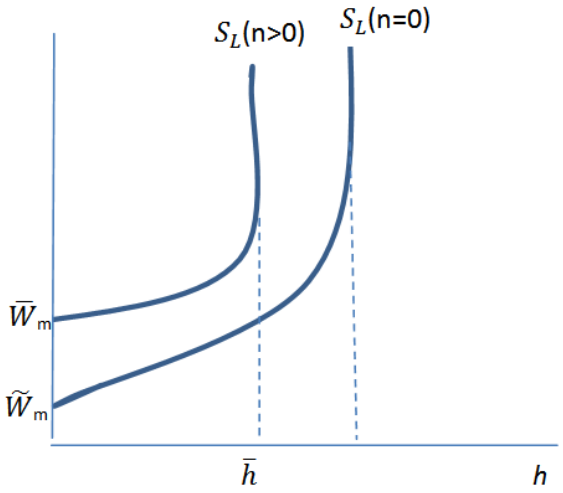

Figure 1. The relationship between the hourly wage rate and the daily hours work supplied by an employee

In order to reduce quasi-fixed costs associated with hiring more employees, the employer prefers to hire the minimum number of employees and to employ them for the maximum number of daily hours. Thus, according to equation (7), the employer prefers to hire employees with few children (low values of n) instead of hiring employees with larger numbers of children, who are more limited in the amount of daily working hours they can supply. We use h_0 to denote the maximum number of daily hours that a single employee can supply if the employee has no childcare obligations, and we assume that, in order to meet his labour requirements, the employer would need to hire N_0 employees supplying h_0 daily working hours each, at an hourly wage rate of W_0.

Another alternative is to hire a larger number of employees, $\hat{N}$, who are parents to several children where $\hat{N} > N_0$, assuming that these employees can work for only $\hat{h}$ daily hours where $\hat{h} < h_0$. This alternative is certain to entail greater costs to the employer than can be compensated for by reducing the hourly wage rate to $\hat{W}$ such that $\hat{W} < W_0$.

2.3. The Demand for Labour Services by Employers

In our model a firm's production function, Q, depends upon the number of "effective daily hours" of work, $\bar{L}$. The production function is defined by the equation:

$$Q = \bar{L}^{\delta} \tag{8}$$

where $0 < \delta < 1$ representing the law of diminishing returns.

The relationship between nominal hours, per employee h, and effective hours, $\bar{L}$, is as follows:

$$\bar{L} = N^{\gamma} h \tag{9}$$

If $\gamma \neq 1$ the relationship between $\bar{L}$ and $L = N \cdot h$ is not one to one.

To justify the claim that $\gamma \neq 1$, we refer to the basic relationship between the number of employees and average number of working hours per employee.

Dixon and Shepherd [55] start with the concept that work hours and the numbers employed are perfect substitutes. Thus, in a very simple framework, the total number of hours worked, L, is a simple product of the number of employees, N, and the average number of hours that each of them worked, h, such that $L = hN$ (hyperbolic curve between h and N for a given L). This means that in terms of output there is no difference, for example, among 10 employees who each supply 8 daily hours of work, 4 employees who each supply 20 daily hours of work, and 80 employees who each supply 1 daily hour of work. In an environment in which hiring an employee entails a fixed cost to the employer regardless of the labour the employee provides, one would expect the employer to seek to minimize the number of employees hired and to maximize the daily hours of labour supplied. Yet in practice this is unlikely to be an optimal approach.

We suggest a different form of labour supply, $\bar{L} = N^{\gamma} h$ instead of $L = Ah^{\alpha} \cdot N$ in the notations of Dixon and Shepherd [55], where $\alpha \neq 1$. In such a case, for a given hourly wage and cost per employee employed, we have to determine the optimal combination of N and h in order to supply a given effective quantity of labour $\bar{L}$ that minimizes production costs. If the optimal average number of hours per employee cannot be achieved, we will consider reducing the wage rate in order to reduce the employment cost until we obtain an optimal and desirable solution.

The following section examines the issue of the penalty, in terms of wages, that is imposed by the employer on part-time employees.

2.4. Why is the Part-Time Employee Paid a Lower Hourly Wage?

The wage reduction is considered a penalty on the wage flexibility of employees who are willing to be employed for fewer daily hours. This is further discussed below.

An employer's total labour cost is determined by the number of employees employed, regardless of the number of daily hours and the total number of hours they spend working. The costs of the latter are the expenses for working hours, equal to the hourly wage multiplied by the total number of hours worked by all employees irrespective of the arrangement of daily hours. In addition, quasi-fixed costs are paid per employee without regard to the respective number of hours worked. Such quasi-fixed costs include expenses for recruitment, training and termination of employment as well as nonwage benefits that are not proportional to working hours, such as healthcare and life insurance benefits. Quasi-fixed costs increase proportionately with the number of employees, regardless of the number of hours each spends at work. Therefore, a workplace in which quasi-fixed costs are relatively high is likely to employ a lower proportion of part-time employees. Such firms are likely to prefer maintaining a large number of working hours for a small number of employees [56,57,58].

In addition, some places of employment are subject to greater cost pressures than others and are thus likely to use flexible staffing arrangements to reduce those costs such as wage and payroll costs, pensions, administrative and employment costs, hiring costs etc [59].

In the papers referenced above, the flexibility is generated towards the benefit of the employer who considers it his or her decision variable. The present paper considers flexibility in terms of average daily working hours determined in "advance" by the employee according to a socioeconomic variable such as having children, family status etc. Flexibility in the present analysis is the decision of the employee that is "forced" on the employer. The employer's response is in the compensation paid to the employee at a lower hourly rate due to the employee's reduced daily working hours.

It is emphasized that in the present model the daily hours of work are the constraint faced by the employer and the wage he or she pays to the employee is the decision variable subject to the constraint.

Some employers attempt to offset the quasi-fixed costs of employment by reducing the wages for part-time employees. This alters the trade-off that firms face in allocating labour input between hours per employee and the number of employees hired [56,60]. Rosen [61] also demonstrates the relationship in a competitive labour market between hourly wage and the length of each shift. Thus, in addition to influencing the composition of employment in the labour market (i.e., the optimal labour ratio between full-time and part-time employees [62]), quasi-fixed costs of labour may be associated with lower wages for part-time employees [57,63].

The preceding discussion raised several considerations that justify the penalty imposed on the part-time employee by wage reduction. However, several other reasons explain some wage gaps between part-time and full-time employees that are also referred to as unjustified wage discrimination.

Hourly wages might be positively affected by the number of hours an employee works for several more potential reasons: According to Hardoy and Schøne [63], "One characteristic of monopsonistic discrimination is wage differences between workers that have approximately the same productivity." (p. 22). Employers might discriminate

against certain employees on the basis of personal characteristics such as race, sex, or religion [64]. Abramo and Valenzuela [65] suggest that despite the increasing entry of women into the work force, discrimination prevents women from receiving equal pay. Another form of discrimination focused upon in this paper is discrimination against part-time employees. Such discrimination is closely related to discrimination against women, who are more likely than men to work part-time. Hardoy and Schøne [63] also claim that because part-time employees are often the second breadwinner in the household, their mobility may be more restricted than that of full-time employees and as a result the labour supply of part-time employees may be less elastic. Employers might exploit this monopsony power and pay lower wages to part-time employees. The authors cited above claim to have "focused on the role of self-selectivity in determining wage differentials between part-time and full-time workers" (p. 20). They did not obtain strong evidence that part-time workers are underpaid, and concluded that "Small wage differences between part-time and full-time work might be regarded as a means of stimulating female labour force participation" (pp. 20, 21).

Based on the previous section we define for any given level of $\bar{L}$ a corresponding combination of n and L as follows:

$$N = (\frac{\bar{L}}{h})^{\frac{1}{\gamma}} \tag{10}$$

Assuming given levels of W_0 , the net hourly wage rate, and $\bar{P}_N$, the hiring cost per employee, our objective is to minimize the total cost of production, i.e., to identify the optimal quantities h_0 and N_0 that guarantee cost minimization.

Based on equation (9) and equation (10), above, the cost function is defined as:

$$\begin{aligned} TC_0 &= W_0 \cdot h_0 \cdot N_0 + \bar{P}_N \cdot N_0 \\ &= W_0 h_0 (\frac{\bar{L}}{h_0})^{\frac{1}{\gamma}} + \bar{P}_N (\frac{\bar{L}}{h_0})^{\frac{1}{\gamma}} \end{aligned} \tag{11}$$

In order to minimize TC we take the F.O.C. derivative with respect to L_0 (see also Appendix I) as follows:

$$\frac{\partial TC}{\partial h_0} = \bar{L}^{\frac{1}{\gamma}} \left[W_0 \left(1 - \frac{1}{\gamma}\right) h_0^{-\frac{1}{\gamma}} - \frac{1}{\gamma} \bar{P}_N h_0^{-\frac{1}{\gamma}-1} \right] = 0 \tag{12}$$

From equation (12) we derive the optimal h_0 as:

$$h_0 = (\frac{1}{\gamma - 1}) \frac{\bar{P}_N}{W_0} \tag{13}$$

Based on equation (13) we define h_0 as a function of $\bar{P}_N$, γ and W_0 regardless of the required output level $\bar{L}$.

According to equation (13) the value of h_0 is:

$$h_0 = \frac{\bar{P}_N}{W_0(\gamma - 1)}$$

and since $N_0^{\gamma} h_0 = \bar{L}$ we find that:

$$N_0^{\gamma} \frac{\bar{P}_N}{W_0(\gamma - 1)} = \bar{L}, \tag{14}$$

and therefore:

$$N_0 = [\frac{\bar{L} W_0 (\gamma - 1)}{\bar{P}_N}]^{\frac{1}{\gamma}} \tag{15}$$

We assume there is a value $\hat{h} < h_0$, where $\hat{h}$ is determined by employees and h_0 is the maximum ideal number of daily working hours from the perspective of the employee while there is a completely inelastic labour supply, such that $\hat{N}$ employees working for $\hat{h}$ hours yield $\hat{N}^{\gamma} \hat{h} = \bar{L}$ where $\hat{N} > N_0$.

Therefore:

$$\hat{N} = (\frac{\bar{L}}{\hat{h}})^{\frac{1}{\gamma}} \tag{16}$$

Based on the four values of $h_0, N, \hat{L}$ and $\hat{N}$, we can define the optimal total costs TC_0 as well as the actual total costs $\widehat{TC}$ under the constraint of the inefficient value $\hat{h}$ as follows:

$$\begin{aligned} TC_0 &= W_0 \cdot h_0 \cdot N_0 + \bar{P}_N \cdot N_0 \\ &= W_0 [\frac{\bar{P}_N}{W_0(\gamma - 1)}] [\frac{\bar{L} W_0 (\gamma - 1)}{\bar{P}_N}]^{\frac{1}{\gamma}} + \bar{P}_N [\frac{\bar{L} W_0 (\gamma - 1)}{\bar{P}_N}]^{\frac{1}{\gamma}} \\ &= \bar{L}^{\frac{1}{\gamma}} \{ [\frac{\bar{P}_N}{W_0(\gamma - 1)}]^{\frac{\gamma - 1}{\gamma}} W_0 + \bar{P}_N^{\frac{\gamma - 1}{\gamma}} [W_0(\gamma - 1)]^{\frac{1}{\gamma}} \} \end{aligned} \tag{17}$$

and

$$\begin{aligned} \widehat{TC} &= W_0 \cdot \hat{h} \cdot \hat{N} + \bar{P}_N \cdot \hat{N} \\ &= W_0 \hat{h} (\frac{\bar{L}}{\hat{h}})^{\frac{1}{\gamma}} + \bar{P}_N (\frac{\bar{L}}{\hat{h}})^{\frac{1}{\gamma}} \\ &= \bar{L}^{\frac{1}{\gamma}} [(\hat{h})^{\frac{\gamma - 1}{\gamma}} W_0 + \frac{\bar{P}_N}{\hat{h}^{\frac{1}{\gamma}}}] \end{aligned} \tag{18}$$

We can rewrite equation (17) and equation (18) as equation (17') and equation (18') as follows:

$$\begin{aligned} TC_0 &= W_0 h_0^{1 - \frac{1}{\gamma}} \bar{L}^{\frac{1}{\gamma}} + \bar{P}_N \bar{L}^{\frac{1}{\gamma}} h_0^{-\frac{1}{\gamma}} \\ &= \bar{L}^{\frac{1}{\gamma}} (W_0 h_0^{\frac{\gamma - 1}{\gamma}} + \bar{P}_N h_0^{-\frac{1}{\gamma}}) \end{aligned} \tag{17'}$$

and

$$\widehat{TC} = \bar{L}^{\frac{1}{\gamma}} (W_0 \hat{h}^{\frac{\gamma - 1}{\gamma}} + \bar{P}_N \hat{h}^{-\frac{1}{\gamma}}) \tag{18'}$$

or as equations (17") and (18"):

$$TC_0 = (\frac{\bar{L}}{h_0})^{\frac{1}{\gamma}} (W_0 \cdot h_0 + \bar{P}_N) \quad (17'')$$

$$\widehat{TC} = (\frac{\bar{L}}{\hat{h}})^{\frac{1}{\gamma}} (W_0 \cdot \hat{h} + \bar{P}_N) \quad (18'')$$

Dividing equation (17") by equation (18") we obtain the following ratio between the optimal cost TC_0 and the constraint cost $\widehat{TC}$:

$$\frac{TC_0}{\widehat{TC}} = (\frac{h}{h_0})^{\frac{1}{\gamma}} [\frac{W_0 h_0 + \bar{P}_N}{W_0 \hat{h} + \bar{P}_N}] \quad (19)$$

The left term on the right side of the equation is less than one since $\hat{h} < h_0$, whereas the right term in the brackets is larger than 1. In the following we prove that for sufficiently large values of $\bar{P}_N$, $\frac{TC_0}{\widehat{TC}} < 1$.

Based on equation (13) and equation (15) we can conclude that h_0 and N_0 are affected positively and negatively, respectively, by $\bar{P}_N$ and negatively and positively, respectively, by the hourly wage W_0.

If we assume $\bar{P}_N > 0$ then and $N \to \infty$.

In this case, h_0 is larger than $\hat{h}$ while $\hat{N} < N_0$. When $\bar{P}_N$ is relatively higher than W, a different picture is obtained, leading to two related consequences:

a. An increase in $\bar{P}_N$ increases the positive gap between $(h_0 - \hat{h})$ and therefore increases the positive gap of $(\widehat{TC} - TC_0)$.
b. When W_0 increases, h_0 diminishes and becomes closer to $\hat{h}$ and the positive gap between costs, $(\widehat{TC} - TC_0)$, diminishes.

From equation (19) we find that for a given $\bar{P}_N$ and significantly large $\widehat{TC}(\hat{h}, \hat{N}, W_0, \bar{P}_N) \gg TC_0(h_0, N_0, W_0, \bar{P}_N)$.

In this situation we can justify a wage reduction to W_1 such that the employer spends the same amount of money, $\widetilde{TC}$, but instead of using the optimal combination of N_0 employees who are each employed h_0 hours, the employer uses $\hat{N}$ employees who are each employed $\hat{L}$ hours, subject to vertical labour supply by employees who constrain their hours of labour to $\hat{h} < h_0$.

Thus, $\widetilde{TC}$ can be reformulated as follows:

$$\widetilde{TC} = (\frac{\bar{L}}{h_0})^{\frac{1}{\gamma}} (W_0 h_0 + \bar{P}_N) = (\frac{\bar{L}}{\hat{h}})^{\frac{1}{\gamma}} (W_1 \hat{h} + \bar{P}_N) \quad (20)$$

From equation (20) we get:

$$(\frac{\hat{h}}{h_0})^{\frac{1}{\gamma}} = \frac{W_1 \hat{h} + \bar{P}_N}{W_0 h_0 + \bar{P}_N} \quad (21)$$

From equation (21) we get equation (22) (see Appendix II):

$$W_1 = -\frac{\bar{P}_N}{\hat{h}} \left(1 - \left(\frac{\hat{h}}{h_0}\right)^{\frac{1}{\gamma}}\right) + \left(\frac{\hat{h}}{h_0}\right)^{\frac{1-\gamma}{\gamma}} W_0 = -A + \varepsilon W_0 \quad (22)$$

From equation (22) we find that indeed if $\hat{h} < h_0$, then $W_1 < W_0$. Moreover, the relationship illustrates a linear (constant) positive effect of W_0 on W_1 that is equal to $\varepsilon < 1$, in addition to the negative value of $(-A)$, the left term of the equation.

Using simulations we can find for any given value of W_0 (given all other values of $N_0, \hat{N}, h_0, \hat{h}, \bar{P}_N$) the optimal wage rate W_1 that compensates the employer who is thus required to decrease the number of daily working hours to increase the number of employees.

The results of a set of such simulations are shown in Figure 2, where W_1 is a function of W_0 maintaining $W_1 < W_0$ for various values of ε.

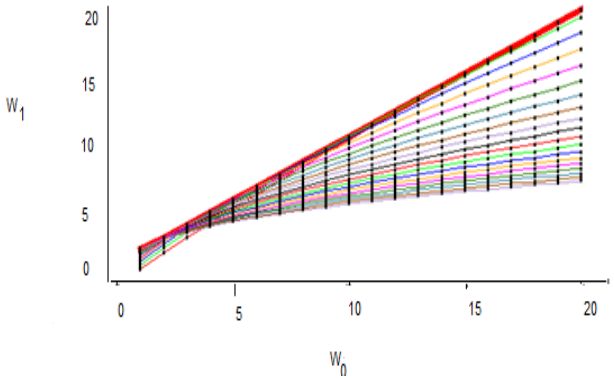

Figure 2. The compensated optimal wage rate W_1 for any given level of W_0

2.5. A numerical Example

To illustrate the applicability of equation (22) we provide the following numerical example:

Let us assume that in order to produce an output $\bar{Q}$ the employer needs $\bar{L} = 1000$ effective labour hours. Let the parameter values be as follows: $\gamma = 2$ (thus, $\bar{L} = 1000 = N^2 h$); the original given wage rate of $W_0 = 1$; and the cost of employing each employee $\bar{P}_N = 20$.

The cost function is:

$$W_0 \cdot h_0 \cdot N_0 + \bar{P}_N \cdot N_0 = 1 \cdot h_0 \cdot N_0 + 20 \cdot N_0$$

$$= 1 \cdot h_0 \cdot \left(\frac{1000}{h_0}\right)^{\frac{1}{2}} + 20 \cdot \left(\frac{1000}{h_0}\right)^{\frac{1}{2}}$$

$$= 1000^{\frac{1}{2}} \cdot h_0^{\frac{1}{2}} + 20 \cdot 1000^{\frac{1}{2}} \cdot h_0^{-\frac{1}{2}}$$

In order to minimize this function for optimal h_0 we take the derivative of the function with respect to h_0:

$$\frac{\partial TC}{\partial h_0} = \left(\frac{1000^{\frac{1}{2}}}{2} \right) h_0^{-\frac{1}{2}} - \frac{20}{2} 1000^{\frac{1}{2}} h_0^{-\frac{3}{2}} = 0$$

Therefore $h_0 = 20$ and $N_0 = \left(\frac{1000}{20} \right)^{\frac{1}{2}} = 50^{\frac{1}{2}}$

$$TC_0 = 1 \cdot 20 \cdot 50^{\frac{1}{2}} + 20 \cdot 50^{\frac{1}{2}} = 40 \cdot 50^{\frac{1}{2}} = 282.82$$

This value is the minimum total cost that is required in order to obtain effective labour hours of $\bar{L} = 1000$. If we assume that the actual number of labour hours per employee is $\hat{h} < h_0$ such that $\hat{h} = 10$ and not the optimum of $h_0 = 20$, then this requires $\hat{N} = 10$ and therefore $\widehat{TC}$, the cost under the constraints imposed by $\hat{h}$ and $\hat{N}$, is as follows:

$$\begin{aligned} \widehat{TC} &= W_0 \cdot \hat{h} \cdot \hat{N} + \bar{P}_N \cdot \hat{N} \\ &= 1 \cdot 10 \cdot 10 + 20 \cdot 10 = 300 > 282.82 = TC_0 \end{aligned}$$

Based on equation (22) we can find that:

$$\begin{aligned} W_1 &= -\frac{20}{10} \cdot \left(1 - \left(\frac{1}{2} \right)^{\frac{1}{2}} \right) + \left(\frac{10}{20} \right)^{-\frac{1}{2}} \\ &= -0.586 + 1.414 = 0.8282 < 1 = W_0 \end{aligned}$$

A wage reduction from $W_0 = 1$ to $W_1 = 0.8282$ is a fair wage reduction since it guarantees that $\hat{N} = 10$ and $\hat{h} = 10$ for $\bar{L} = 1000$, leading to $\mathrm{TC} = 0.8282 \cdot 10 \cdot 10 + 20 \cdot 10 = 282.82$ as required.

3. Results and Conclusions

Labour market flexibility plays an important role in the Human Resource Management literature. It can take many forms, among them the employment of temporary or part-time rather than full-time employees. Hiring temporary employees to meet variations in demand for staffing over the day, week, month or year, reduces expenses by allowing employers to take on temporary employees as needed rather than engaging permanent staff. Temporary employees can replace regular employees who are absent due to sickness or vacation, or bolster the workforce for special projects, such as corporate restructuring or mergers. Outsourcing work increases the efficiency of the work performed in-house and allows the company to meet the fluctuations of seasonal peak demand. The employment of part-time employees meets the problems of scheduling outside regular business hours, a common feature of sales and service jobs. Flexibility in staffing to adapt to variable demand may actually serve to protect the job security of the company's permanent employees when there is a decline in demand. This must be reflected in the relationship between the employment contract and the organizational environment, i.e., customizing HRM policies to the needs of the organization.

The present study adds another dimension of labour flexibility in the field of HRM, with respect to the appropriate wage gaps between part-time and full-time employees. Human resource management should consider wage gaps very carefully. Labour market flexibility, and specifically daily hours of working time flexibility, can benefit both employers and employees. The present paper proposes a model for capturing the trade-off between the labour requirements of an employer and the labour supply offered by an employee that often is assumed to be inelastic, e.g., because of child care requirements or other family and social obligations in the employee's personal life. Our model assumes that the hourly cost of employing a part-time employee is higher than the hourly cost of employing a full-time employee. This is due to the quasi-fixed costs incurred by the employer for each employee he or she hires, regardless of the number of hours worked. The study demonstrated how the employer should be compensated for this cost difference by offering part-time employees a lower hourly wage than that of full-time employees. The part-time employee is penalized in the hourly wage rate in return for the flexibility in daily working hours, while the employer who is restricted in hiring the part-time employee gains flexibility in the hourly wage rate.

The study contributes to an ongoing discussion regarding the wage gap between part-time and full-time employees. Previous literature has offered various explanations for this wage gap, including compensating for wage differences (i.e., employees are willing to "pay" for the privilege of flexibility), as well as monopsonistic discrimination. The present paper proposes a method of computing a "fair" wage rate for part-time employees that is driven by purely financial considerations which ensure that neither employers nor employees are penalized by the employment arrangement. The optimal wage identified can serve as a benchmark for a "justifiable" wage gap (referred to as "wage differences") between part-time and full-time employees.

Policymakers or the labour force manager of a firm can rely upon it when attempting to identify either actual cases of wage discrimination, in which firms exploit their monopsonistic power and indeed underpay part-time employees; or cases in which the wage is reduced in a "fair way."

Future research could extend the present study in several directions. First, it would be of interest to empirically explore the extent to which firms indeed implement discriminatory practices against part-time employees. In particular, future researchers could investigate whether certain industries are more likely than others to engage in such practices, or whether certain populations e.g., women, foreign employees, or unskilled employees, are more likely to be discriminated against. The computation of the "fair" wage rate for part-time employees is based in part on the relationship between the needs of employers, which are likely to vary across industries; and the actual supply of labour by employees, which is assumed to be inelastic. This should be taken into account when evaluating the fair wage for specific industries and employee populations. More generally, it would be of interest to gain empirical insight into the true relationship among the part-time wage level, the labour requirements of employers, and the constraints of

employees. Future studies could also empirically evaluate the breakdown of employer costs associated with hiring and employing employees, in order to obtain a more accurate model of wage differences and wage discrimination.

Part-time employment has grown over the last thirty years due to the fact that is has helped employees to combine career and family life (especially mothers with small children). This represents the supply side of the labor market. However, the demand side of the labor market should also be considered. Is part-time employment a burden or an advantage for the employees? Specchia and Uandenberghe [66] claim that empirical estimations remain inconclusive.

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Appendix I

Another way to derive TC_0 is by minimizing TC with respect to n. Based on (9) and (10) the objective is:

$$\begin{aligned} Min_n TC &= W_0\left(\frac{\bar{L}}{N^{\gamma}}\right)\mathrm{N} + \bar{P}_N N \\ &= W_0 \cdot \bar{L} \cdot N^{1-\gamma} + \bar{P}_N N \end{aligned} \tag{1.1}$$

F.O.C. is

$$\frac{dTC}{dN} = (1-\gamma) W_0 \cdot \bar{L} \cdot N^{-\gamma} + \bar{P}_N = 0 \tag{1.2}$$

S.O.C.

$$\frac{d^2 TC}{dN} = (-\gamma)(1-\gamma) W_0 \cdot \bar{L} \cdot N^{-(\gamma+1)} > 0 \tag{1.3}$$

only for $\gamma > 1$

From (1.2) we get

$$N^{\gamma} = (\gamma - 1)\frac{W_0}{\bar{P}_N}\bar{L} \tag{1.4}$$

Therefore we can define optimal N_0 as follows

$$N_0 = \left[(\gamma - 1)\frac{W_0}{\bar{P}_N}\bar{L}\right]^{\frac{1}{\gamma}} \tag{1.5}$$

By (10) and (1.5) we get

$$1 = (\gamma - 1)^{\frac{1}{\gamma}}\left(\frac{W_0}{\bar{P}_N}\right)^{\frac{1}{\gamma}} h_0^{\frac{1}{\gamma}} \tag{1.6}$$

Thus

$$h_0 = \left(\frac{\bar{P}_N}{W_0}\right)\left(\frac{1}{\gamma - 1}\right) \tag{1.7}$$

As we can see from (1.7) the conclusion with respect to h_0 is obtained regardless of the levels of $\bar{Q}$ and $\bar{L}$. The only variable affected by the production scale is N_0, the optimal number of employees.

This conclusion is similar to our result in (13).

Appendix II

$$\left(\frac{\hat{h}}{h_0}\right)^{\frac{1}{\gamma}} = \frac{W_1\hat{h} + \bar{P}_N}{W_0 h_0 + \bar{P}_N} \tag{2.1}$$

$$(\frac{\hat{h}}{h_0})^{\frac{1}{\gamma}}\left(W_0h_0+\overline{P}_N\right)=W_1\hat{h}+\overline{P}_N \tag{2.2}$$

$$W_1=\frac{(\frac{\hat{h}}{h_0})^{\frac{1}{\gamma}}\left(W_0h_0+\overline{P}_N\right)-\overline{P}_N}{\hat{h}} \tag{2.3}$$

$$W_1=\frac{(\frac{\hat{h}}{h_0})^{\frac{1}{\gamma}}\left(W_0h_0+\overline{P}_N\right)}{\hat{h}}-\frac{\overline{P}_N}{\hat{h}} \tag{2.4}$$

$$W_1=\hat{h}^{\frac{1}{\gamma}-1}\left(W_0h_0^{\,1-\frac{1}{\gamma}}+\frac{\overline{P}_N}{h_0^{\frac{1}{\gamma}}}\right)-\frac{\overline{P}_N}{\hat{h}} \tag{2.5}$$

$$W_1=\hat{h}^{\frac{1}{\gamma}-1}\left(W_0h_0^{\,1-\frac{1}{\gamma}}\right)+\hat{h}^{\frac{1}{\gamma}-1}\frac{\overline{P}_N}{h_0^{\frac{1}{\gamma}}}-\frac{\overline{P}_N}{\hat{h}} \tag{2.6}$$

$$W_1=\hat{h}^{\frac{1}{\gamma}-1}\left(W_0h_0^{\,1-\frac{1}{\gamma}}\right)+\frac{\hat{h}^{\frac{1}{\gamma}}}{\hat{h}}\frac{\overline{P}_N}{h_0^{\frac{1}{\gamma}}}-\frac{\overline{P}_N}{\hat{h}} \tag{2.7}$$

$$W_1=\hat{h}^{\frac{1}{\gamma}-1}\left(W_0h_0^{\,1-\frac{1}{\gamma}}\right)+\frac{\overline{P}_N}{\hat{h}}\left(\left(\frac{\hat{h}}{h_0}\right)^{\frac{1}{\gamma}}-1\right) \tag{2.8}$$

$$W_1=-\frac{\overline{P}_N}{\hat{h}}\left(1-\left(\frac{\hat{h}}{h_0}\right)^{\frac{1}{\gamma}}\right)+W_0\frac{\hat{h}^{\frac{1}{\gamma}-1}h_0}{h_0^{\frac{1}{\gamma}}} \tag{2.9}$$

$$W_1=-\frac{\overline{P}_N}{\hat{h}}\left(1-\left(\frac{\hat{h}}{h_0}\right)^{\frac{1}{\gamma}}\right)+W_0\frac{\hat{h}^{\frac{1}{\gamma}}}{\hat{h}}\frac{h_0}{h_0^{\frac{1}{\gamma}}} \tag{2.10}$$

$$W_1=-\frac{\overline{P}_N}{\hat{h}}\left(1-\left(\frac{\hat{h}}{h_0}\right)^{\frac{1}{\gamma}}\right)+W_0\left(\frac{\hat{h}}{h_0}\right)^{\frac{1}{\gamma}}\frac{h_0}{\hat{h}} \tag{2.11}$$

$$W_1=-\frac{\overline{P}_N}{\hat{h}}\left(1-\left(\frac{\hat{h}}{h_0}\right)^{\frac{1}{\gamma}}\right)+W_0\left(\frac{\hat{h}}{h_0}\right)^{\frac{1}{\gamma}}\left(\frac{\hat{h}}{h_0}\right)^{-1} \tag{2.12}$$

$$\begin{aligned}W_1&=-\frac{\overline{P}_N}{\hat{h}}\left(1-\left(\frac{\hat{h}}{h_0}\right)^{\frac{1}{\gamma}}\right)+W_0\left(\frac{\hat{h}}{h_0}\right)^{\frac{1}{\gamma}-1}\\&=-\frac{\overline{P}_N}{\hat{h}}\left(1-\left(\frac{\hat{h}}{h_0}\right)^{\frac{1}{\gamma}}\right)+W_0\left(\frac{\hat{h}}{h_0}\right)^{\frac{1-\gamma}{\gamma}}\end{aligned} \tag{2.13}$$

$$W_1=-\frac{\overline{P}_N}{\hat{h}}\left(1-\left(\frac{\hat{h}}{h_0}\right)^{\frac{1}{\gamma}}\right)+\left(\frac{\hat{h}}{h_0}\right)^{\frac{1-\gamma}{\gamma}}W_0=-A+\varepsilon W_0 \tag{2.14}$$

Derivatives

$$\frac{\partial W_1}{\partial W_0}=\left(\frac{\hat{h}}{h_0}\right)^{\frac{1-\gamma}{\gamma}}$$

$$\begin{aligned}\frac{\partial W_1}{\partial \hat{h}}&=\overline{P}_N\hat{h}^{-2}+\frac{\overline{P}_N}{h_0^{\frac{1}{\gamma}}}\left(\frac{1}{\gamma}-1\right)\hat{h}^{\frac{1}{\gamma}-2}+W_0\left(\frac{1}{\gamma}-1\right)\hat{h}^{\frac{1}{\gamma}-2}h_0^{\,1-\frac{1}{\gamma}}\\&=\overline{P}_N\hat{h}^{-2}+\left(\frac{1}{\gamma}-1\right)\hat{h}^{\frac{1}{\gamma}-2}\left(\frac{\overline{P}_N}{h_0^{\frac{1}{\gamma}}}+W_0h_0^{\,1-\frac{1}{\gamma}}\right)\\&=\overline{P}_N\hat{h}^{-2}+\left(\frac{1}{\gamma}-1\right)\hat{h}^{\frac{1}{\gamma}-2}\left(\frac{\overline{P}_N+W_0h_0^{\,1-\frac{1}{\gamma}}h_0^{\frac{1}{\gamma}}}{h_0^{\frac{1}{\gamma}}}\right)\\&=\overline{P}_N\hat{h}^{-2}+\hat{h}^{\frac{1}{\gamma}-2}\left(\frac{1}{\gamma}-1\right)\left(\frac{\overline{P}_N+W_0h_0}{h_0^{\frac{1}{\gamma}}}\right)\end{aligned}$$

$$\begin{aligned}\frac{\partial W_1}{\partial \gamma}&=\frac{\overline{P}_N}{\hat{h}}\left(\frac{\hat{h}}{h_0}\right)^{\frac{1}{\gamma}}\ln\frac{\hat{h}}{h_0}\left(-\gamma^{-2}\right)+\frac{W_0h_0}{\hat{h}}\left(\frac{\hat{h}}{h_0}\right)^{\frac{1}{\gamma}}\ln\frac{\hat{h}}{h_0}\left(-\gamma^{-2}\right)\\&=\left(\frac{\hat{h}}{h_0}\right)^{\frac{1}{\gamma}}\ln\frac{\hat{h}}{h_0}\left(-\gamma^{-2}\right)\left(\frac{\overline{P}_N}{\hat{h}}+\frac{W_0h_0}{\hat{h}}\right)\\&=\left(\frac{\hat{h}}{h_0}\right)^{\frac{1}{\gamma}}\ln\frac{\hat{h}}{h_0}\left(-\gamma^{-2}\right)\left(\frac{\overline{P}_N+W_0h_0}{\hat{h}}\right)\end{aligned}$$