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# Factor Price Elasticity of Demand


**Ian St John**

**Economics Department**

**istjohn@habselstree.org.uk**


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# Factor Price Elasticity of Demand

## Ian St John

### Abstract

This article analyses Factor Price Elasticity of Demand (FED), being a measure of the responsiveness of demand for a factor of production to a change in its price. FED was first investigated systematically by Alfred Marshall, who formulated four laws of derived factor demand. Using isoquants and isocost curves we disaggregate the effect of a factor price change into substitution and scale effects. Together these effects yield the 'fundamental law of factor demand', which states that price elasticity of demand for a factor of production depends on the share of that factor in total costs, the ease of factor substitution in production, and the price elasticity of demand (PED) for the final product. This model confirms three of Marshall's four laws of factor demand. His fourth law, that the elasticity of demand for a factor is lower the lower the share of the factor in total costs, is shown to be true only when the elasticity of factor substitution is less than the electricity of demand for the finished product (i.e. when the substitution effect of a factor price rise is less than the scale effect). Empirical estimates suggest that Wage Elasticity of Demand (WED) is about unitary, which means a 10% increase in wages for most types of labour will cause a 10% fall in employment. But for some skilled jobs like pilots this figure is much lower (since it is hard to substitute capital for pilots, pilot salaries are a small share of total airline costs, and the PED for air travel is inelastic). By contrast, the WED for unskilled labour is greater than one, and is particularly high for younger workers – which means that rises in the minimum wage for young people may significantly reduce employment.

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Factor Price Elasticity of Demand (FED) is a measure of the responsiveness of the quantity of a factor input demanded to a change in its price. It is measured as follows:

$$\mathcal{E}\text{d} = \frac{\text{Percentage Change in the Quantity of Factor Demanded}}{\text{Percentage Change in its Price}}$$

$$\mathcal{E}\text{d} = \frac{\frac{\Delta \text{F}}{\text{F}}}{\frac{\Delta \text{PF}}{\text{PF}}} = \frac{\text{PF}}{\text{F}} \frac{\Delta \text{F}}{\Delta \text{PF}}$$

Where:

F = Quantity of factor input employed

PF = Price per unit of factor input

The price elasticity of demand for a factor is always a negative number, since a rise in the price of a factor input will cause a fall in the quantity of the factor employed and *vice versa*. When the percentage change in factor demand is *greater than* the percentage change in its price we say demand for the factor is **elastic**; when the percentage change in demand for a factor is *less than* the percentage change in its price we say that demand for the factor is **inelastic**; and when the percentage change in the demand for a factor is *equal to* the percentage change in its price we say that the elasticity of demand for the factor is **unitary**.

The importance of the FED is that it enables us to predict what will be the effect of a change in the price of a factor on the demand for that factor. Let us assume that the output of a good (Q) is a function of the input of two factors, capital and labour. Thus:

Q = Q(K, L)

Where Q is output per unit of time and K and L are the inputs of capital and labour services per unit of time respectively.

The question of how far a given percentage change in factor price will impact upon the demand for a factor was analysed by the Cambridge economist Alfred Marshall in his *Principles of Economics*. Marshall put forward what have become known as his four *laws of derived demand* – derived, because the demand for factor inputs derives, ultimately, from the demand for the products they produce.[1] Marshall's 'laws' can be expressed as follows:

1. *The price elasticity of demand for a factor will be less elastic the harder it is to substitute another factor for it in the production process.* Or as Marshall expressed it: 'The first condition is that the factor itself should be essential, or

[1] A. Marshall, *Principles of Economics* (Macmillan, London, Eighth Edition, 1920), p. 385.

nearly essential, to the production of the commodity, no good substitute being available at a moderate price.'

2. *The price elasticity of demand for a factor will be less elastic the lower is the price elasticity of demand for the product of the factor*. 'The second condition', writes Marshall, 'is that the commodity in the production of which it is a necessary factor, should be one for which the demand is stiff and inelastic …'
3. *The price elasticity of demand for a factor input will be less elastic the lower is the elasticity of supply of alternative factor inputs.*
4. *The price elasticity of demand for a factor will be less elastic the lower is that factor's share in the total costs of production.*

To better understand Marshall's laws of derived demand it is useful to approach them through the conceptual framework of isoquants and isocost curves.

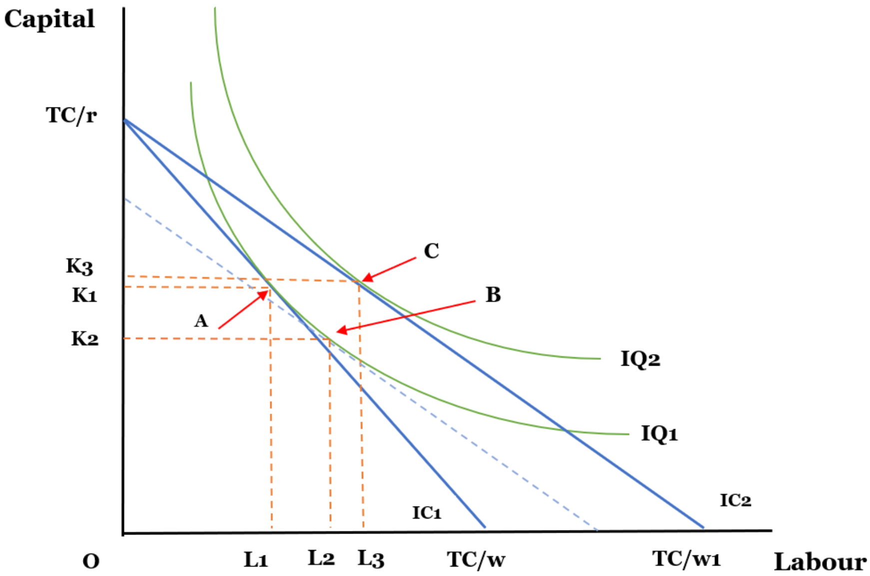


**Figure 1. Determining Demand for Labour and Capital using Isoquants**

An isoquant is a line showing different combinations of factor inputs yielding a given level of output. In the diagram we assume two factor inputs, capital and labour. The isoquant IQ1 is drawn for a given fixed level of output. This given output can be produced by using different combinations of capital and labour. For example, point A is a point on the isoquant IQ1 and is produced using K1 of capital and L1 of labour. Point C is another point on the same isoquant, utilising less capital (K2) and a larger amount of labour (L2). The ratio of the change in capital input to the change in the labour input as we move down a given isoquant is the Marginal Rate of Technical Substitution of labour for capital:

$$MRTS_{LK} = -\frac{\Delta K}{\Delta L}$$

The MRTS is always negative since, if K decreases, L must increase and *vice versa* if we are to hold output constant. As the change in capital diminishes, the degree to which labour inputs need to change to keep output constant also diminishes – which is to say that C tends towards A. Hence ΔK/ΔL tends towards dK/dL, which is the gradient of the isoquant at point A. Thus:

$$MRST_{LK} = -\frac{dK}{dL}$$

Thus, the MRTS is equal to the gradient of an isoquant. It depends upon the ratio of the Marginal Productivities of the two factors. This can be shown by taking the total differential of the production function:

$$Q = f(K, L)$$

$$dQ = \frac{\partial Q}{\partial K}dk + \frac{\partial Q}{\partial L}dL$$

Since dQ = 0 for a given isoquant (output is constant), then:

$$\frac{\partial Q}{\partial K}dk + \frac{\partial Q}{\partial L}dL = 0$$

$$\frac{\partial Q}{\partial K}dk = -\frac{\partial Q}{\partial L}dL$$

$$\frac{dK}{dL} = -\frac{\partial Q/\partial L}{\partial Q/\partial K} = \frac{MPL}{MPK}$$

Where MPL and MPK are the marginal products of labour and capital respectively.

An isocost line shows the different combinations of capital and labour a firm can use for a given cost outlay. For each given level of Total Costs there is a different isocost line. If a firm has two factor inputs, capital and labour, and the cost per unit of labour time used (e.g. one hour) is the wage rate w, and the rental cost per time unit of capital employed is r, then the firms Total Costs are:

$$TC = wL + rK$$

Where L is the amount of labour in hours and K is the amount of capital services in hours. Expressing this in terms of K:

$$rK = TC - wL$$

$$K = \frac{TC}{r} - \frac{w}{r}L$$

This is a linear function. The intercept of the vertical axis, when the firm only buys capital and employs no labour at all, is TC/r, i.e. the total spending on inputs divided by the price per unit of capital, r. Clearly if we divide a total amount of cost spending by the price per unit of capital, we arrive at the total amount of capital the firm can acquire. The *slope* of the line is w/r, which is determined by the ratio of input prices. The higher the wage rate, or the lower the rental price of capital, the steeper the isocost line – which again makes sense: if a firm employs less capital, the amount of extra labour it can employ is larger if the wage is low or the cost of capital is high. In **Figure 1** we start with isocost line IC1, corresponding to a price of capital r and a wage rate of labour w.

Suppose the firm wishes to produce output Q at the lowest possible cost. What combinations of capital and labour will it employ? We can easily answer this question by combining isoquants with isocost curves. In the case of *cost minimisation*, we take a given output as fixed and to this there corresponds exactly one isoquant – such as IQ1. We then shift an isocost line inwards until it is *just tangential to the isoquant*. This is the lowest possible cost at which a given output can be produced given the available technology and factor prices. The point at which this tangency position occurs on the isoquant will yield the cost-minimisation combination of capital and labour. This is point A in the diagram, where IC1 is tangential to IQ1, corresponding to a capital input of K1 and a labour input of L1.

At the tangency point A the gradient of the isoquant is equal to the gradient of the isocost line. That is:

$$\frac{dK}{dL} = \frac{w}{r}$$

We already know that the gradient of the isoquant is the MRTS which is equal to:

$$\frac{dK}{dL} = -\frac{\partial Q/\partial L}{\partial Q/\partial K} = \frac{MPL}{MPK}$$

It therefore follows that a cost-minimising firm will employ that combination of capital and labour where:

$$\frac{MPL}{MPK} = \frac{w}{r}$$

Having established this rule, we are in a position to analyse the effect on the demand for a factor such as labour of a change in its price. This effect has two components:

1. A substitution effect of a factor price change
2. A scale effect of a factor price change

**Substitution Effect of a Factor Price Change**

The substitution effect of a factor price change is the effect of a change in the price of a factor on the demand for that factor *whilst holding output and the price of other* *factors constant.* For example, imagine that the wage rate of labour falls from w to w1, where w1 < w. Given that the equation of the isocost line is:

$$K = \frac{TC}{r} - \frac{w}{r}L$$

the effect of a fall in w relative to r is to cause the gradient of the icocost line to diminish – that is to say, become flatter. For a given Total Cost outlay, the firm can now purchase more labour than before if it devotes all spending on inputs to labour, and hence the point at which the isocost line crosses the x-axis pivots out from TC/w to TC/w1 in **Figure 1**.

Since the firm minimises costs when:

$$\frac{MPL}{MPK} = \frac{w}{r}$$

the fall in the wage rate means that:

$$\frac{MPL}{MPK} > \frac{w1}{r}$$

Hence, the firm is no longer operating at its optimal combination of factor inputs. Since the wage and price of capital are given to the firm, the only way it can restore its cost-minimising position is to increase the ratio of the marginal product of labour to the marginal product of capital. It does this by decreasing its usage of capital and increasing its use of labour. As more labour is employed relative to capital the marginal product of labour falls due to the law of diminishing returns, while the marginal product of capital rises as there is less capital relative to labour. So MPL falls and MPK rises until the firm re-establishes its cost minimising combination of labour and capital where:

$$\frac{MPL}{MPK} = \frac{w1}{r}$$

Thus, the effect of a fall in the price one factor input compared to other factor inputs is, when holding total output constant, to cause that factor to be substituted for others in the production process. This is the *substitution effect* of a change in the price of a factor. The substitution effect is *always* negative: that is, holding all other things constant, a fall in the price of a factor will always cause demand for that factor to increase and *vice versa*.

This substitution effect of a factor price change is illustrated in **Figure 1**. The fall in the wage rate causes the isocost line to pivot out from IC1 to IC2, corresponding to the lower gradient of the line, w1/r. To isolate the substitution effect we hold output constant at IQ1 and drag the new isocost line (IC2) back until it is tangential to the original isoquant. The new point of tangency, B, reflects the new lower gradient of the isocost line and shows how a firm, whilst holding output constant, will substitute labour for capital as the relative price of labour falls, consequently moving *down* the isoquant from point A to point B. As a result, capital inputs fall from K1 to K2, while labour inputs increase from L1 to L2.

This change in the relative employment of factor inputs due to a change in the relative price of those factors is called the **Elasticity of Factor Substitution**. It is calculated as follows:

$$\text{Elasticity of Factor Substitution} = \sigma = \frac{\frac{d\left(\frac{K}{L}\right)}{K/L}}{\frac{d(MRTS)}{MRTS}} = \frac{\frac{d\left(\frac{K}{L}\right)}{K/L}}{\frac{d(w/r)}{w/r}}$$

The Elasticity of Substitution measures the degree to which a change in relative factor prices [d(w/r)] compared to the initial ratio of factor prices (w/r) will bring about a change in the relative use of factors in the production process (i.e. a change in the ratio of capital to labour K/L). When $\sigma = 0$, and the two factors must be used in fixed proportions, a relative rise in (say) wages will *not* cause any tendency for firms to substitute capital for labour; when $\sigma$ tends to $\infty$ then a small rise in wages will cause an extremely large change in the relative utilisation of capital and labour; while if $\sigma = 1$ then a relative increase in wages relative to the rental price of capital will cause an equal percentage change in the capital-to-labour ratio. Studies tend to suggest that the Elasticity of Factor Substitution is about 0.8, so that a 10 per cent fall in the ratio of wages compared to the price of capital will cause an 8 per cent fall in the ratio of capital to labour as labour is substituted for capital.

**Scale Effect of a Factor Price Change**

Thus far we have assumed that the firm's output will remain unchanged when the price of labour falls. But this was a simplification to isolate the substitution effect of the price change. In fact, a firm's output will change when the price of one factor changes, and when the price of one factor input declines the optimal output of the firm will *increase*. So, in our example, a fall in w while r remains constant will *lower* the costs of the firm. For a given cost-outlay the firm can produce *more* than before. This is what is shown by the isocost line pivoting out from IC1 to IC2. For the same cost-outlay as before the firm now has access to greater combinations of labour and capital. In particular, with the new isocost line the maximum amount the firm can produce is represented by the higher isoquant IQ2 corresponding to an increased output, with the optimal tangency point between the isocost and isoquant lines occurring at point C. What this means is that the overall effect of a fall in the wage rate has been to cause the firm to move from point A to point C, with the total employment of labour increasing from L1 to L3 and the employment of capital rising from K1 to K3. This total increase in demand for labour reflects the operation of two effects: the movement from L1 to L2 is due to the *substitution effect* of a fall in the wage rate relative to the price of capital; while the movement from L2 to L3 is the *scale effect* reflecting the increase in the firm's total output as its production costs fall. The size of the scale effect depends upon how much the firm's output changes as a result of a change in the price of a factor input.

This in turn depends on two things: the share of that factor in the total costs of the firm and the effect of a change in the output of the firm on the price of its finished product. For note that, in conditions of imperfect competition, if a firm increases its output due to a fall in the wage rate, then the *price* at which that output will sell *falls* as the firm moves down the demand line for its product. And this in turn depends on the Price Elasticity of Demand for the product in question.

**The Fundamental Law of Factor Demand**

The substitution and scale effects of a change in factor price determine the overall effect of a change in factor price on the demand for that factor; hence it is these effects which determine the Price Elasticity of Demand for a Factor of production.

$$\mathcal{E}\mathrm{d} = -\,(1 - \mathrm{S_L})\sigma + \mathrm{S_L}\eta$$

Where:

$\mathcal{E}\mathrm{d}$ = Factor price elasticity of demand

$\mathrm{S_L}$ = the share of output going to labour. Equal to $\mathrm{wL/Y}$ where Y is total output.

$\sigma$ = Elasticity of factor substitution

$\eta$ = Price elasticity of demand for the final product. $\eta < 0$.

This formula assumes constant returns to scale – which is to say, if all factor inputs are increased by some percentage then total output increases by the same percentage. In this case total output will be wholly distributed between the factor inputs (labour and capital) so $S_L + S_K = 1$, where $S_K$ is the output going to capital (rK/Y). Thus:

$$\mathcal{E}\mathrm{d} = -\,(\mathrm{S_K})\sigma + \mathrm{S_L}\eta$$

Daniel Hamermesh, in his book *Labor Demand*, calls this equation 'the fundamental law of factor demand.'[1] It incapsulates both the substitution and scale effects of a factor-price change and Marshall's first two laws of derived demand for a factor.

Take first the substitution effect. In this case, we hold output constant, so the elasticity of factor demand depends only on the change in relative factor prices. Thus:

$$\mathcal{E}\mathrm{d} = -\,(1 - \mathrm{S_L})\sigma$$

$$\mathcal{E}\mathrm{d} = -\left(1 - \frac{\mathrm{wL}}{\mathrm{Y}}\right)\sigma$$

[1] D.S. Hamermesh, *Labor Demand* (Princeton University Press, Princeton, 1993), p. 24.

The elasticity of demand for a factor such as labour is smaller (less negative) the lower (closer to zero) is the elasticity of factor substitution (σ), which is to say, the harder it is to substitute capital for labour in the production process. This parameter is technically determined. The substitution effect also depends on the share of labour in the total costs of the firm. The *higher* is labour's share of output the *lower* is the elasticity of demand for labour due to the substitution effect. This sounds counter-intuitive. What it means is that when production is labour intensive, with not much capital being used, then it is hard to substitute capital for labour in the production process. For example, suppose work on a farm involves 100 workers using 5 spades. Then if the wages of workers increase it is hard to shift significantly from workers to spades: even an increase of capital of 20 per cent will only increase the number of spades from 5 to 6 and it will be difficult to displace many workers with just one spade! Production is still likely to remain labour intensive. Thus, this simplified equation gives us Marshall's first law of derived demand: the own price-elasticity of demand for factor input is lower the harder it is to substitute another factor for it within the production process.

The scale or output effect is:

$$\varepsilon d = -S_L\eta$$

The scale effect of a change in factor price depends on two things: first, the share of that factor in the total costs of the firm ($S_L$); and second, the price elasticity of demand for the final product (η). This corresponds to Marshall's second and fourth laws. Taking the example of labour, an increase in the wage of labour will have a smaller effect on the final demand for labour the lower is labour's share of total costs ($S_L$). If labour's share of total costs is small, then the effect of an increase in wages on total costs will be small and hence output will fall by less and price rise by less. By contrast, if labour's share of costs is high, then a wage increase will have a larger effect on total costs, output, and price, causing a larger fall in demand for labour due to the scale effect. This is Marshall's fourth law (we return to this below). Second, the lower is the price elasticity of demand for the final product (η) then the less will final demand fall for a given rise in price and hence the smaller will the reduction in output and fall in demand for labour. If price elasticity of demand is elastic then a given rise in price resulting from an increase in costs will cause demand to fall significantly, leading to a larger scale effect in the demand for labour. This is Marshall's second law.

What of Marshall's third law? This states that the elasticity of demand for one factor depends on the elasticity of supply of another. This can be seen quite simply. Taking the case of labour, if the wage rate rises the firm will want – according to the substitution effect – to substitute capital for labour. But if the supply of capital is perfectly inelastic then no more capital is available. In this case the substitution effect will be zero and only the scale effect will be operable. The wage elasticity of demand for labour will be less. Taking a less extreme case, if the supply curve of capital is upward sloping, then an increased demand for capital will raise the price of capital (r) relative to w, so reducing the initial substitution effect of the rise in w. In terms of the isocost equation:

$$K = \frac{TC}{r} - \frac{w}{r}L$$

a rise in r will lower the intersection point of the isocost curve with the y-axis and diminish the line's gradient. A rise in the wage will accordingly have a reduced effect on the demand for labour. Only if the supply of capital is perfectly elastic to the firm will our fundamental demand for labour equation completely hold.

**'The Importance of Being Unimportant'? Marshall's Fourth Law Again**

Marshall's fourth law of derived demand states that elasticity of demand for a factor will be lower the smaller the share of total costs accounted for by that factor. This sounds intuitively plausible. In the case of labour, if labour's share of total costs ($S_L$) was 20 per cent, then a 10 per cent increase in the wage of labour would raise costs by 10 x 0.2 = 2 per cent. This is a small increase in costs, and hence we might anticipate that the scale effect of reduced output and lower employment of labour would be small. By contrast, if labour accounted for 50 per cent of total costs, then a 10 per cent rise in wage rates would increase costs by 10 x 0.5 = 5 per cent. In this case, an equal increase in wages has more than double the effect on the firm's costs. Hence, we would expect the output and demand effect for labour to be larger – as Marshall suggests.

However, in his *The Theory of Wages* (1932), John Hicks pointed out that Marshall had overlooked the *elasticity of factor substitution* in his analysis. Marshall's fourth law is couched solely in terms of the scale effect of a cost change. But what about the substitution effect? If labour has an increased wage rate then, in terms of the substitution effect alone (holding output constant), the effect will be a *fall* in demand for labour. This substitution effect must be incorporated into the analysis. If the elasticity of factor substitution is less than the price elasticity of demand for the finished product, then Marshall's fourth law holds: when a factor accounts for a small share of total costs and firms cannot easily substitute another factor for it within the production process, then the scale effect of an increase in wages is more important than the substitution effect and *then* being a small share of total costs will ensure than few units of that factor will be dispensed with in production. However, if the elasticity of factor substitution *exceeds* the price elasticity of demand then the *substitution* effect of an increase in factor price will be *larger* than the scale effect: in effect, firms find it easier to substitute factors than consumers do products. In this case, demand for the factor will fall significantly even if it is a small part of total costs. Being a 'small' component of costs won't save a factor from the effects of an increase in its price if it can be easily substituted for within the production process.

George Stigler gave a vivid example to illustrate this point. Take, he said, the contribution of carpenters in the building of a house. Suppose carpentry is a significant proportion of the construction costs. Then, on Marshall's reasoning, their elasticity of demand for labour would be quite high since a rise in carpenter wages would have a notable effect on the price of houses and construction demand for carpenters would fall due to the scale effect. Now suppose, Stigler continues, that 'we classify the carpenters who build a house into Polish, German, Irish, and so on. Since the wages of any one group of national origin will be a small fraction of total cost … can we not say that the elasticity of demand for Irish carpenters is smaller than the elasticity of demand for all carpenters?' In terms of Marshall's fourth law, of course, we could: if Irish carpenters' wages are just, say, 3 per cent of costs, then an increase in the wages of Irish carpenters would have virtually no effect on the price of houses and the scale effect on the demand for Irish carpenters would be negligible. But, obviously, this would be wrong, for if *Irish* carpenters went on strike and demanded a pay rise, then building firms would simply substitute Italian, German, or any other group of carpenters for them. In this case the substitution effect would far outweigh the scale effect and the Marshallian Irish carpenters would find themselves unemployed to a man![1]

Indeed, in those cases where the substitution effect is more important than the scale effect of a factor price change, the role of the share of that factor in total costs is precisely the opposite of what Marshall argued. Remember that the substitution effect of a factor price change alone is:

$$\mathcal{E}\mathrm{d} = -(1 - S_L)\sigma$$

As we discussed above, the *larger* is the share of a factor in total costs the *smaller* is the substitution effect of a factor price change. Filer, Hamermesh, and Rees provide another example. Consider, they say, the example of an orchestral company. This company employs 80 musicians who play the music and 5 ushers who collect ticket money and help people to their seats. Assume the wages of both types of labour are initially the same. The wages of musicians account for 80 per cent of costs while the ushers are far fewer and account for just 5 per cent. Suppose the ushers get a pay rise. It would be quite easy for the firm to substitute musicians for ushers: even if only two were moved from music to collecting ticket money, the demand for ushers would fall by 40 percent – a high elasticity of demand for ushers. By contrast, if musicians got a pay rise, it would be hard for the firm to substitute ushers for musicians even assuming they could actually play the instruments. Moving two ushers (who have become relatively cheaper as their wages have *not* increased) across to playing in the orchestra would reduce demand for musicians by just 2.5 per cent. In this example, being a small share of costs *increases* the elasticity of demand effect for a factor of production since substitution in production will be easier and less expensive if a smaller amount of labour needs to be replaced.[2]

### Evidence Regarding the Elasticity of Factor Demand

There have been well in excess of 100 studies of the price elasticity of demand for factors of production – at economy, industry, and firm level. Most of these studies

[1] G. Stigler, *The Theory of Price* (Macmillan, New York, Third Edition, 1966), p. 244.
[2] R. Filer, D. Hamermesh, and A. Rees, *The Economics of Work and Pay* (Harper Collins, New York, Sixth Edition, 1996), pp. 156-158.

have focused on the wage elasticity of demand for labour at firm or industry level. Further, most have studied the *substitution* effect of a wage change; far fewer have incorporated the scale effect, which is harder to assess. What these studies show is that the wage elasticity of demand for labour due to the substitution effect alone (holding output constant) ranges between -0.15 and -0.75 at firm or industry level, with -0.3 being considered a fair overall average.[1] In a recent 2023 article, ‘How Elastic is Labour Demand? A Meta-Analysis for the German Labor Market’, Martin Popps concluded that, for the German economy, ‘the estimates for the own-wage elasticities of labor demand average −0.43 for the German labor market.’[2] The range and frequency of estimates within the sample Popps collected is shown in **Figure 2**.

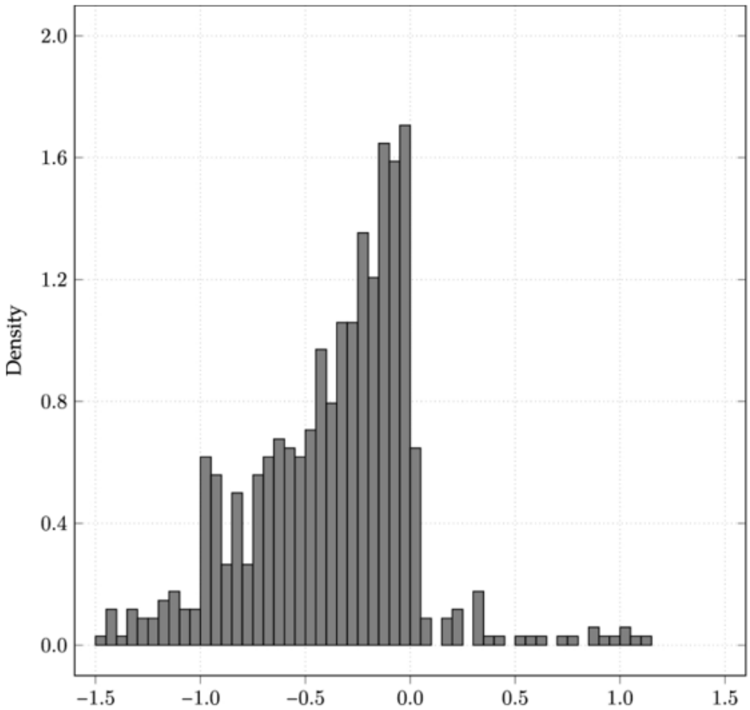


**Figure 2. Relative Frequency of Different Estimates of Wage Elasticity of Demand in Germany[3]**

These figures conform to earlier studies by Hamermesh and others. Estimates of scale elasticity of demand suggest an average figure of -0.7. This means that the overall elasticity of demand for labour is -0.3 + -0.7 = -1 or unitary. That is to say, a ten per cent increase in wages causes a ten per cent fall in demand for labour and *vice versa*.[4] The demand curve for labour indeed slopes downwards. Not surprisingly, evidence also suggests that the elasticity of demand for *skilled* labour is lower than that for *unskilled*: an observation reflecting the lower elasticity of substitution (σ) between skilled labour and capital.[5] Unskilled labour is more easily substitutable by

[1] Hamermesh, *Labor Demand*, p. 103
[2] M. Popps, *Journal for Labour Market Research*, Vol. 57, Number 14 (2023).
[3] Cited *ibid*.
[4] Filer, Hamermesh, and Rees, *Economics of Work and Pay*, p. 164.
[5] Hamermesh, *Labor Demand*, p. 126.

capital. For teenagers, estimates as high as -7 or -9 have been arrived at for the wage elasticity of demand: an increase in the wages of young people will cause a significant reduction in their employment – a powerful reason for caution in raising the minimum wage for young workers.[1]

The wage elasticity of demand model we have developed here helps to explain real-world wage variation between jobs. If we consider roles such as pilots and train drivers, we can see why those workers and their unions have been able to push for high wage increases with limited employment effects. In both cases the wages of pilots and train drivers, though high, are a small share of total costs, and demand for the finished product it inelastic. Hence the *scale* effect on demand for both kinds of labour of a wage increase will be small. Further, the *substitution* effect will be small since it is almost impossible to substitute capital or unskilled labour for the job of a pilot or train driver. The elasticity of factor substitution will be low.

## Conclusion

The concept of price elasticity of demand for a factor of production is an important tool for explaining the effects of price changes of factors on the operation of firms and industries. Analysis has largely confirmed the initial insights of Marshall regarding the determinants of the derived demand for a factor: that it depends on the ease of substitution within production of one factor for another; the share of the factor in total costs; and the price elasticity of demand for the final product. The effect of a change in the price of a factor consists of substitution effects arising out of the *relative* change in factor prices and scale effects arising out of the change in a firm's *output* owing to the effect of a change in the price of a factor on the firm's costs and hence its output. Both operate in the same direction such that a rise in wages, for example, will cause a firm to substitute capital for labour, while the rise in the firm's costs will cause its price to rise and demand for its product to fall. Statistical studies suggest that the two effects together cause the wage elasticity of demand for labour to be around minus one, such that a ten per cent rise in the wage rate of labour will cause in the long run a ten per cent fall in the demand for labour – though this is an average figure, with larger effects for unskilled labour and smaller effects for skilled.

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[1] R. Ehrenberg and R. Smith, *Modern Labour Economics* (Harper Collins, New York, Fourth Edition, 1991), pp. 117-18.