A.C. PIGOU’S THE THEORY OF UNEMPLOYMENT
AND ITS CORRIGENDA: THE LETTERS OF
MAURICE ALLEN, ARTHUR L. BOWLEY, RICHARD
KAHN AND DENNIS ROBERTSON

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Karen Knight

Business School
University of Western Australia

DISCUSSION PAPER 14.08
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ABSTRACT
Shortly after the appearance of the first printing run of A.C. Pigou’s *The Theory of Unemployment*, Macmillan and Company made available to purchasers a Corrigenda slip. Reviewers of the book identified additional errors and slips, particularly in Pigou’s mathematical work. This paper considers the broad evolution of Pigou’s economic thought on unemployment and the implications of unpublished correspondence discovered in the Marshall Library archives alerting Pigou to errors appearing in the first printings of *The Theory of Unemployment*. Pigou’s departure from the Marshallian tradition of placing mathematics in the background of economic theorising, and reasons why his 1933 text required a substantial corrigenda, are examined. It is argued that the impact of Pigou’s treatise on unemployment on the development of economic thought extended beyond its contributions to unemployment theory.
1. Introduction

Pigou’s *The Theory of Unemployment* was published in 1933 during the height of the Great Depression. The book differed from Pigou’s earlier published books on economic thought in two related ways. First, the audience targeted was specifically students of economics “to clarify thought, not to advocate a policy” (1933, p. v). Pigou’s previously published books had at least been accessible to an audience “other than professional economists”. Second, Pigou pointedly informed his readers that he was departing from his mentor and predecessor Alfred Marshall’s customary style of relegating mathematics to the background of economic argument, questioning whether Marshall’s audience would not have “been better off had mathematical ideas been presented to them in mathematical form” (1933, p. vi) rather than presented in a fashion where the true meaning might remain not completely understood. Pigou instead produced a highly abstract and analytical study on unemployment that liberally employed differential calculus.

This paper has three goals. First, a brief overview of the development of Pigou’s economic thought on unemployment is presented so that *The Theory of Unemployment* is considered in the context of his long-term research agenda spanning the years of his early career up until 1933. Second, the significance and historical relevance of hitherto unpublished correspondence, stored in the Marshall Library archives at Cambridge University, discussing the use of mathematics in the first printing of Pigou’s *The Theory of Unemployment* is reflected upon. The correspondence, comprising of letters and cards to Pigou from Maurice Allen, Arthur L. Bowley, Richard Kahn and Dennis Robertson, were stored by Pigou within the pages of his personal copy of *The Theory of Unemployment*. A contribution of this paper is the demonstration that many elements of this correspondence were the source
for Pigou’s corrigenda issued for *The Theory of Unemployment* and reflection on reasons why Pigou did not utilise all of the suggestions from his correspondents. Third, the paper investigates reasons for Pigou’s amplification of mathematical reasoning and modelling in *The Theory of Unemployment* which explicitly broke from the Marshallian inspired practice of limiting the use of mathematics in economic text.

The first goal of the present study is addressed in Sections 2 and 3 of the paper. Specifically, an overview of the evolution of Pigou’s economic thought on unemployment in the years leading up to publication of *The Theory of Unemployment* is presented in Section 2; and a brief account of the basic model that Pigou developed in *The Theory of Unemployment* is provided in Section 3. The second goal of the study is addressed in Section 4, which features a discussion of the nature and significance of the unpublished correspondence with Pigou on errors in *The Theory of Unemployment*. The final goal of the study is addressed in Section 5, which reflects on the changes in, and impact of, Pigou’s method in *The Theory of Unemployment*. The paper concludes in Section 6 by reconsidering the impact of *The Theory of Unemployment*, the contributions of which extended beyond Pigou’s development of unemployment theory.

2. The Evolution of Pigou’s Theories on Unemployment

During his early career Pigou considered unemployment as a by-product of two distinct levels of maladjustment in economic activity. These levels of maladjustment may be referred to as “micro” and “macro” economic failures with consequences that prevent the achievement of full employment (in an occupation or for an economy in aggregate). Of course, the terms “micro” and “macro” economic maladjustments were not Pigou’s, but they are used in this overview to highlight that these two distinct perspectives were largely evident from the commencement of
Pigou’s research agenda on unemployment. His “micro” analysis of economic behaviour arose from his considerations of the changed landscape of industrial relations and labour markets in the early twentieth century and his “macro” analysis of economic activity emerged from his consideration of the issue of free trade and welfare.1

Pigou outlined his early “micro” analysis of unemployment in his book *Principles and Methods of Industrial Peace* (1905), which examined the nature of maladjustments arising from “normal” supply and demand conditions of labour markets. However, Pigou also noted that maladjustments could occur in labour markets both in space (in terms of the organisation of labour mobility via the development of institutional framework including “agencies for moving people, spreading information and cultivating foresight”) as well as time (in terms of lags between supply and demand), and on average would affect levels of variation in employment in the economy as a whole. Pigou’s early “macro” analysis of unemployment concerned considerations of maladjustments arising from variations in “normal” labour market conditions caused by relative levels of stability in the economy in the aggregate. These arguments arose from Pigou’s analysis of protectionism and were initially articulated in *The Riddle of the Tariff* published in 1903 and three years later in an essay, “Protection and the Working Classes” (1906).

In a retrospective piece, Pigou (1952a, pp. 85-107) recalled the impact of two events that, he believed, had generally led economists to consider unemployment as a topic requiring greater analysis.2 These two events were: the Royal Commission on

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1 The perennial protectionism v. free trade question re-emerged as heated and controversial policy debate in Great Britain after the Government’s decision to tax imported corn as a revenue raising exercise to cover costs associated with the Boar War. Pigou was actively engaged in these debates.

2 This chapter appearing in *Essays in Economics* was originally published as an article in *Agenda* in 1944 as “Employment Policy and Sir William Beveridge”.

3
the Poor Laws and Relief of Distress 1905-09 (and its subsequent report *The Majority and Minority Reports of the Royal Commission on the Poor Laws* issued in 1910); and the appearance of Beveridge’s popular book *Unemployment, a Problem of Industry* published in 1909. The Commission’s focus on unemployment was to be reflected in Pigou’s inaugural address in 1908 as Professor of Political Economy at Cambridge delivered shortly after his involvement with the Commission. Pigou notably highlighted unemployment as a pressing topic of research in economics and emphasised methodological issues, stressing the pressing need for the systematic collection of accurate statistical material. Pigou’s address included a concise summation of maladjustments which caused unemployment arising from two sources: fundamental labour market forces (i.e. microeconomics of maladjustments in the labour market), and industrial fluctuation (i.e. macroeconomics of maladjustments in the labour market), accompanied by a consideration of possible remedies.

Pigou subsequently built his analysis of unemployment within his wider studies, *Wealth and Welfare* (1912), and the much larger and expanded volume, *The Economics of Welfare* (1920). Between these two volumes, Pigou (1914) produced a small volume for general readership entitled *Unemployment*. In his 1912, 1914 and 1920 texts, Pigou’s consideration of unemployment was entwined with a systematic analysis of effects on the national dividend from the deliberate transferences of resources from the relatively rich to the relatively poor (through interfering with the}

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3 It has been argued that neither Marshall, nor Pigou provided any substantial analysis of unemployment to the Royal Commission, with Pigou’s (1910 [1907]) contribution confined to analysis of pauperism, wage adjustment and considerations of minimum wages and minimum living conditions (Komine, 2007; McBriar, 1987, p. 258). Komine (2007) also observes that the analytical structure adopted in the memorandum was present in Pigou’s later seminal work, *Wealth and Welfare* published five years later.

4 McBriar (1986, p258 footnote 21) notes T.W. Hutchinson’s (1953, p.416) dating of Pigou’s interest in public works as a counter-cycle policy to Pigou’s inaugural lecture as Professor of Political Economy at Cambridge in 1908 and also links this to Pigou’s engagement with the Commission.
natural wage-rate, or by government or philanthropic intervention) and the consideration of industrial fluctuation.\(^5\)

Pigou noted in the opening pages of *The Economics of Welfare* that economic constants (supply and demand) were dependent upon human consciousness such that the “actual substance with which economic study deals means that the goal sought is itself perpetually shifting” (1920, p.10). During the 1920s Pigou seemed particularly aware of this aspect of economic science. Observing great change in Britain’s social and economic landscape, Pigou contemplated the impact of these changes upon his economic analysis during the course of this decade. Four prominent features of the changes occurring in Great Britain during this period were: a real economy characterised by structural change and high levels of unemployment; monetary disarray; political turmoil; and institutional changes in the labour market arising from increased labour representation.

Great Britain’s real economy had been affected since the turn of the 20\(^{th}\) century by a decline in traditional export industries of coal and cotton in the absence of development in new industry. Combined with the diminution of restoration demands in the wake of World War I during the early years of the decade, high levels of unemployment remained a feature of Great Britain’s industrial landscape throughout the 1920s unlike other booming industrialised nations (notably the United States). Britain’s economy was further characterised by monetary disarray. Having abandoned the Gold Specie Standard at the outbreak of the First World War, Britain’s government became committed to the restoration of the Gold Standard during the

\(^5\) For discussion from different perspectives concerning tensions between Pigou’s economic thought on distribution and efficiency related to minimum wages and the setting of a national minimum see Flatau (1997), Komine (2007) and Takami (2009).
decade which further exacerbated unemployment levels.\textsuperscript{6} Political turmoil and industrial unrest coincided with Britain’s economic difficulties. The 1924 general election in Great Britain was the third to have been held in less than two years. Britain’s first labour government, formed with liberal support and led by Ramsay MacDonald, had won election earlier in 1924 only to be defeated by Stanley Baldwin’s conservative majority nine months later. Baldwin’s conservative government then pursued a balanced budget in order to return to the Gold Standard during 1925 which only proved to worsen export conditions for British industry. With industrial conditions deteriorating further, a general strike was called by the Trade Union Congress in 1926 in order to place pressure on the British government to prevent wage reductions and improve conditions of striking miners.\textsuperscript{7}

It was against this socio-political background that Pigou reassessed his earlier analysis of unemployment by considering more closely the interdependencies between different forms of labour market maladjustments (micro and macro). In particular, the role of money, and the distinction between real and nominal influences, started to play a more prominent role in his thinking about unemployment.\textsuperscript{8} For example, Pigou’s consideration of the relationship between money and wages is evident in his empirical paper of 1923, “Prices and Wages from 1896-1914” which examined the relationship between money rates of wages and price movements. Pigou examined the argument that “economic friction causes the money rate of wages to lag behind prices” (p.165), and was interested in the interdependence between “extra-monetary” and “non-monetary” causes affecting decreases in the real wage. In a

\textsuperscript{6} Pigou served in his capacity as a professional economist on the Cunliffe Committee on Foreign Exchange (1918-19) and the Chamberlain Committee on the Currency and the Bank of England Note Issue (1924-25), the latter Committee having recommended a return to the Gold Standard.

\textsuperscript{7} See Martin Pugh (2009) for a detailed account of the social history of Britain between the wars.

\textsuperscript{8} Collard (1981, p 119) notes Pigou’s explicit dichotomisation of real and monetary factors in the famous 1918 article, “The Value of Money”, articulating the Cambridge cash balance approach.
chapter contribution to the edited book *Is Unemployment Inevitable?* entitled “Correctives of the Trade Cycle” published the following year, Pigou (1924) broadly outlined the relationship between real and monetary factors impacting business cycles, noting that “though, monetary and banking arrangements do not play that overruling part in the causation of these cycles which is sometimes assigned to them, they do play a very important part” (p. 98). Pigou observed that at times these factors impacted and amplified the effects of business cycles on prices and business confidence. However, although Pigou generally advocated Irving Fisher’s currency plan and discount policy to affect price stability, he considered that on practical grounds “to introduce large changes [to the monetary system] the meaning of which most people cannot understand” was dangerous. In his consideration of the relationship between polity and community inherent in the development of economic policy, Pigou noted that “elaborate improvements in our monetary system … [were] not practical” (p. 121).

During the same year consideration of the variability of the national dividend was omitted from the second (of four) editions of *The Economics of Welfare* in order to “undertake a more comprehensive study of industrial fluctuations”. Pigou’s broadened analysis of business cycles, *Industrial Fluctuations* published in 1927, considered a range of aggregate level effects on demand, both in terms of institutional monetary arrangements and international exchange, and real effects on industrial

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9 Fisher’s plan as outlined in *The Purchasing Power of Money* (1922) entailed a central authority buying and selling currency in terms of bullion so as to maintain “a par, not with a fixed weight of gold, but with such a weight of gold as should have a fixed purchasing power” in order to effect price stabilisation (p. 342).

10 Norikazu Takami (2011b) has recently argued that Pigou developed his analysis of unemployment during the 1920s with a tacit understanding of an incompatibility between the economic aims of: a fixed currency, extended social policies, and low unemployment. And that contemporary political constraint on affecting remedies to mitigate unemployment via monetary policy led Pigou to focus on the impacts of wage rigidity.
stability including changes in tastes, the impact of new technology, and the psychological states of businessmen which could lead to errors in forecasting. Aslanbeigui (1992) notes Pigou’s sources of macroeconomic variability as three broad categories: real, psychological and monetary. It is the relationship between real wages examined by Pigou in *Industrial Fluctuations* which he returns to in *The Theory of Unemployment* (1933). Pigou included in *Industrial Fluctuations* a consideration of the relationship between industrial fluctuations via unemployment rates and real wages from the period between the 1880s to 1914, concluding generally that real wages were higher when employment was good and lower when it was bad (1927a, pp 217-9). Pigou’s (1927b) article “Wage Policy and Unemployment” published in the *Economic Journal* the same year, however, placed emphasis on the new post-war phenomenon of wage rate rigidity in exacerbating unemployment rates and related this change directly to changes in labour market institutions and government policy in Great Britain (minimum wages and public unemployment insurance).

In the intervening years between his 1927 paper and the appearance of *The Theory of Unemployment* in 1933, Pigou would be called to testify at the Macmillan Committee formed by the British government in 1929 to examine the causes of Britain’s depressed economy. The relationship between economists and government became markedly formalised during this time with the formation of Economic Advisory Committee (EAC) during 1930. The Macmillan Committee Hearings and the EAC provided a forum in which theoretical differences between economists were aired and differences in theoretical positions, and expression of the complexity of the problem of unemployment during this time often led to a lack of consensus (Howson & Winch, 1977, p. 158). By 1933, the requirement for a rigorous analysis of unemployment which could disentangle its various causes became crucial in an
environment which Pigou implicitly recognised consisted of political and social constraints upon policy adoption based upon advice drawn from economic science. The development of Pigou’s own analysis of unemployment had also reached a level of complexity which required a method of expression, capable of describing interdependencies between micro and macro levels of economic behaviour, and which required a language from which the fruits from the pursuit of economic knowledge could be relayed to both polity and community. Pigou’s economic thought and method, however, emerged from deeper epistemic currents in intellectual and scientific endeavours which itself was a response to broad cultural changes in the wake of the industrial revolution and world war. These changes and how Pigou’s contributions were embedded in these changes will be considered more closely in Section 5 of this paper.

Pigou’s (1920, p.10) recognition of broad changes in the states of human consciousness “shifting the goal” of economic reasoning can be seen in action in his own theory development concerning unemployment. In order to align his analysis of unemployment in the face of observed broad socio-economic changes, Pigou unravelled various elements of his analysis of unemployment over the course of three decades leading up to the appearance of *The Theory of Unemployment*: bifurcating monetary and real effects; and examining in detail both microeconomic and macroeconomic aspects in his analysis of unemployment. In 1933 he attempted to bring these elements together in a general theory of unemployment, in order to “break new ground” in economic thought by examining “a simplified model of the economic world rather than that world itself” which he self-consciously proclaimed could only “yield more than a rough approximate picture of the facts”.

9
3. The Theory of Unemployment – An Overview of the Basic Model

Pigou’s Theory of Unemployment deals with a sequence of real interdependencies associated with the demand for the provision of raw materials, the short run demand for final goods, and the demand for labour. Pigou then attempts to introduce the interdependence between real and monetary influences on labour markets with the aid of his notion of the elasticity in the demand for labour. The concept of ‘elasticity’ is the central analytical mechanism for dealing with these interdependencies throughout the book and the theoretical basis for such analysis is developed across the various chapters in Part II of the book entitled “The Short Period Elasticity of the Real Demand for Labour”. As this title suggests, with the form and quantity of industrial equipment generally assumed to be fixed. The relevance of this is that the sensitivity of employment to wages identified in the short period will be associated with larger variations once industrial equipment is permitted to vary over the longer period.

Of the goals that Pigou set for Part II of the Theory of Unemployment, four are of fundamental importance for his short period analysis of unemployment. They are: to formally develop a micro model of variations in the real demand for labour in a particular occupation; to model the theoretical effects on the real elasticity of demand for labour as a whole associated with a change in the period of production; to extend the micro model of variations in the real demand for labour from particular occupations to a model of the aggregate real demand for labour in the macro-economy; and, finally, to formally model the relationship between the elasticities of money demand and aggregate real demand for labour.
3.1 Microeconomics - the real demand for labour in a particular occupation

Pigou commences Part II with his formal ‘microeconomic’ analysis of the real demand for labour for a particular occupation. Through the introduction of the classical analytical device of the ‘wages fund’ doctrine, he links the output of labour goods with the real demand for labour in the particular occupation, such that \( F(x) \) is the function that represents the output of wage-goods produced by the type of labour that produces the wage good; and the real elasticity of demand for labour \( (E_d) \) is:

\[
E_d = \frac{F'(x)}{x} \cdot \frac{1}{F''(x)}
\]  

(1)

Where \( \frac{F'(x)}{x} \) is the ratio of the real wage rate (i.e. wage rate valued in terms of the wage good) to the quantity of labour employed in an occupation (i.e. the wage/price to quantity ratio in a standard elasticity equation); and \( \frac{1}{F''(x)} \) is the inverse of the rate of change in the wage rate with respect to output.

Pigou then defines the scope of his first round of analysis by illustrating how the elasticity relationship for a particular market (the wage good market) and a particular occupation (the occupation of ‘processing’ wage goods) can be adjusted to account for the fact that the services of labour are only used for the processing stage of the production process. To facilitate this, the notion of a short period productivity of labour function, where \( y \) is the number of units of ‘processing’ undertaken by \( x \) units of labour from within the wage good producing occupation, is introduced on the assumption that processing involves one unit of raw materials and one unit of labour; and the elasticity of short period labour productivity is defined -

\[
y = \phi(x)
\]  

(2)
\[ \eta = \frac{\phi'(x)}{x} \cdot \frac{1}{\phi'(x)} \quad (3) \]

Using relations (2) and (3), Pigou extends relation (1), when \( E_d \) represents the real elasticity of demand for labour in a given occupation to process goods into finished goods at works, to account for the influence of the real elasticity of the demand for finished goods at works \( (E_f) \); the elasticity of the supply of raw material product \( (E_s) \); relative per unit demand price of finished product to raw material \( (m) \); and the product of the value of marginal net product and \( x \); divided by the value of the total net product \( \left( \frac{x\phi'(x)}{\phi(x)} \right) \), which equates to the wage rate to per capita output ratio \( (w/q) \) under perfect competition. Given that \( E_d, E_f \) and \( \eta \) are negative and \( m>1 \), Pigou (1933, p45) concluded that the real price elasticity of demand for labour:

- increases in response to an increase in:
  
  (i) the elasticity of demand for finished goods;
  
  (ii) the elasticity of supply of raw materials;
  
  (iii) the elasticity of labour productivity (equation 3); and
  
  (iv) the relative demand price of finished product, to raw material, ratio;

- decreases in response to an increase in:
  
  (i) the wage to output ratio (under free competition).

3.2 The elasticity of real demand for labour and the period of production

Pigou considers the period of production for industry as a whole for the time from when labour is first employed to process a product until that final product has been completely processed. The relevance of the issue to Pigou is the elasticity of

\[ \frac{1}{E_d} = \frac{1}{m-1} \left[ \frac{m}{E_f} - \frac{1}{E_s} \right] \left( \frac{x\phi'(x)}{\phi(x)} \right) + \frac{1}{\eta} \]

\[ \text{(11)} \]

Pigou’s solution to the problem is given by the equation: \[ \frac{1}{E_d} = \frac{1}{m-1} \left[ \frac{m}{E_f} - \frac{1}{E_s} \right] \left( \frac{x\phi'(x)}{\phi(x)} \right) + \frac{1}{\eta} \]
real demand for labour in an occupation is influenced by an expansion or contraction in the period of production; plus a change in the rate of discount. Seymour E. Harris (Harris, 1935, p. 293), in probably the most comprehensive review of Pigou’s book, draws attention to Pigou’s analysis in this chapter as “at once the most original, most difficult and most important analysis in the entire volume”.

Pigou’s derived solution to the problem of time is given by equation 4:

\[
E_d = \frac{1 - \frac{k}{e}}{1 + \frac{k}{eE_r}}
\]  

(4)

Where \( E_d \) is the actual elasticity of demand for labour as a whole, \( E_r \) is the elasticity of real demand for labour prevailing if there were no reactions through the real rate of interest, \( k \) is the length of period of production, and \( e \) the elasticity of discounting for time over the duration of the period of production. When \( k \) tends to zero (the period of production is immediate), or \( e \) tends to infinity (changes in wage goods do not affect the rate of discount), \( E_d \) tends to \( E_r \). When the ratio \( k/e \) is not equal to one, the elasticity of real demand for labour becomes more elastic when the period of production increases; and/or the elasticity of discounting decreases (in correspondence with an increase in the real rate of interest expected on investing in labour processing). But this is entirely a short period analysis. For the longer period, such short period interdependencies might be ignored (Pigou 1933, p. 87).

This chapter is important in terms of the correspondence Pigou received alerting him to mistakes in his mathematical work as it is this chapter of *The Theory of Unemployment* that the majority of the edits which later appear in the Corrigendum are alerted to Pigou by Bowley, Allen (via Fay), and Kahn.
3.3 Macroeconomics: variations in the aggregate real demand for labour

Pigou was particularly concerned with the causation of unemployment “not a sum of separate causes of unemployment, each accountable for so much of it, but rather a system of interconnected factors jointly responsible for the whole of it” (1933, p. 28). However, because of the range of interdependencies between the real demand for labour in different occupations, Pigou concluded that a complete multi-sector analysis was not feasible. However, through use of the notion of the wages good, he felt that aggregate analysis was possible when output was limited to two sectors – and wages goods produced in the wages paid to workers in both sectors, plus a trade surplus for non-wage earners in the wage good industry.

To consider the elasticity of real demand for the economy, Pigou sets some modelling variables and relationships for an economy that comprises of the wage good industry and the export industry.

Basic two sector relationships in Pigou’s Macroeconomic Model:

\[ x \quad \text{the number of employees in the wage good sector} \]
\[ F(x) \quad \text{the output of wage goods in the wage good sector} \]
\[ y \quad \text{the number of employees in non-wage good (export) sector} \]
\[ F'(x) \quad \text{the wage rate in both the wage good and export sectors} \]
\[ \phi(x) \quad \text{demand for labour services (i.e. processing) in aggregate} \]

Then, as Gerhard Michael Ambrosi (2003, p. 59) points out:

\[(x+y)F'(x) = \text{total wage bill across for both sectors}\]

\[F(x) - (x+y)F'(x) = \text{surplus for non-workers in the wage good sector}\]
\( \phi(x) = x + y = \text{aggregate real demand for labour services} \)

Pigou then defines \( \eta \) as the elasticity of the real demand for labour in the wage-good industries and the export industries together. Given the relationships for Pigou’s two sector model outlined above, Pigou derives the solution for \( \eta \) as:

\[
\eta = \frac{F'(x)}{xF'(x)} 
\]

Pigou then sets aside issues associated with the period of production and the rate of discount and defines \( E_r \) as the real demand for labour in aggregate which is represented by the ratio of: the rate of change in the demand for aggregate labour divided by the aggregate demand for labour; to, the rate of change in the real wage divided by the real wage. This is summarised in equation (6) below.

\[
E_r = \frac{\phi'(x)}{\phi(x)} \cdot \frac{F''(x)}{F'(x)} \quad (6)
\]

Given equation (5), equation (6) can be stated as:

\[
E_r = \frac{x\phi'(x)}{\phi(x)} \eta \quad (7)
\]

The importance of equation (7) is that yields relationship whereby the elasticity of real demand for labour in aggregate, is influenced by the relative change in the aggregate demand for labour and the short period labour productivity in the wage good sector. As such, it provides a basis for a more general macroeconomic model,

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12 It should be noted that the function \( \phi(x) \) has changed its meaning from that of Pigou’s discussion of the elasticity of demand for a particular occupation, where \( \phi(x) = y \), with \( y \) being the units of labour services (i.e. processing) undertaken in the wage good industry. In Pigou’s macro-model \( \phi(x) = x + y \), which is the demand for units of labour services in the wage good sector and the non-wage good sector i.e. the aggregate demand for labour services.

13 As the question of the rate of discount is set aside in this macro model of ‘labour as a whole’, there is no account for reactions upon the real elasticity of demand through the real rate of interest.
with aggregate output from the wage good sector allocated across the economy as a whole, with microeconomic foundations for labour market. However, output of the non-wage good sector is not treated within the model, without which aggregate output cannot be related to aggregate employment.\textsuperscript{14}

### 3.4 Macro-economics: elasticities of money demand and real demand for labour.

In chapter X, Part II Pigou extends his elasticity analysis to determine the elasticity of demand in terms of money for labour as a whole by considering the relationship between the elasticity of the real demand for labour, $E_r$, and the elasticity of money demand, $E_m$. Pigou notes that the value of $E_m$ in relation to $E_r$ depends on the nature of the monetary system operating in a particular community. Pigou postulates a system in which aggregate money income, $I$, is a function of the real income of the community and of the quantity of labour employed. That is, when $I = \psi(x)$, where $x$ is the quantity of aggregate labour and when $F(x)$ is the real value of output, expressed in terms of wage-goods, then the equilibrium money wage-rate is:

\[
\frac{F'(x)}{F(x)} I = \frac{F'(x)}{F(x)} \psi(x) \tag{8}
\]

In terms of elasticity, the nominal elasticity of demand taken for labour must account for variations in $\psi(x)$. On the presumption that wages in Great Britain account for two-fifths of total income, and holding constant the aggregate quantity of money income accruing, Pigou calculated derived values of $E_m$ associated with various values of $E_r$. As *The Theory of Unemployment* was drafted in the early 1930s, naturally Pigou provisionally considered the elasticity of demand in terms of money for labour as a whole in times of deep depression. He concluded that the elasticity of

\textsuperscript{14} Gerhard Michael Ambrosi (2003) has examined this issue in some detail and, interestingly, he has reformulated Pigou’s model in a quasi-general-equilibrium choice theoretic framework, with output for the non-wage good sector incorporated.
money demand for labour would be “not less numerically than -1.5”, which lead him to conclude that a 10 per cent cut in money wages would, “other things being equal”, result in more than a 10 per cent expansion in the aggregate volume of labour demanded (1933, p. 106). Pigou, however, emphasised the phrase “other things being equal” and cautioned that other influences may tend to deepen depressed conditions and the “expansive effect of the reduction would be partly or wholly masked”.

4. The Theory of Unemployment’s Corrigenda

Various contemporaneous reviews of The Theory of Unemployment point to the number of minor errors in the mathematical work as detracting from Pigou’s analysis. From letters folded and stored inside Pigou’s personal copy of The Theory of Unemployment held in the Marshall Library Archives, it is now evident that Pigou was advised directly, or indirectly, of a number of errors by correspondence shortly after the book was published. The correspondence includes: a letter from Richard Kahn to Pigou dated 13th August, 1933 (Appendix 1); a letter from Arthur L. Bowley to Pigou dated 30th August, 1933, attaching extensive mathematical corrections and alternative mathematical expression (Appendix 2); an undated letter from Maurice Allen15 to Charles Ryle Fay (Appendix 3), also attaching mathematical corrections and alternative expression; and an undated postcard from D.H. Robertson to Richard Kahn (Appendix 4).

Macmillan and Company archival records indicate that two thousand copies of The Theory of Unemployment were listed for printing in June of 1933 (Macmillan Publishers Limited Archivist, 2012). The Book was first published on July 4, 193316 and, in Roy Harrod’s (1934) review appearing in The Economic Journal, a note was

15 At the time (William) Maurice Allen was a fellow and tutor in economics at Balliol College.
16 By 1946, The Theory of Unemployment is recorded in Macmillan and Company archival records as being out of print (Macmillan and Company Archivist, 2012).
added indicating that Macmillan will, upon application, provide a separate Corrigenda slip that corrects errors in the book.\(^\text{17}\) With the discovery of the above mentioned letters, it is now clear that they are the sources for these corrections outlined in the Corrigenda (see Appendix 5). After the publication of the Corrigenda, reviewers noted a number of further corrections that should be made to the book\(^\text{18}\) and, on 9\(^{\text{th}}\) March, 1938 (well after publication of the Corrigenda) Jose Ros Jimeno, from Valencia, wrote to Pigou pointing out a mathematical error which had previously been identified in reviews of the book.\(^\text{19}\)

In the preface to *The Theory of Unemployment*, Pigou acknowledges the assistance of his colleagues at Cambridge, Dennis Robertson and Peiro Sraffa, for having read all Parts of the manuscript and Parts I and II respectively. Sraffa did not specialise in the formalisation of economics and Robertson tended to eschew the idea of incorporating mathematics in his published work. In addition, from Kahn’s letter to Pigou it is evident that Kahn had read parts of *The Theory of Unemployment* and had checked and provided Pigou with mathematical corrections pertaining to some sections of the book. Kahn does admit, however, to not having given the book a thorough reading at the time of his correspondence (as he was due to holiday in

\(^\text{17}\)The Corrigenda to *The Theory of Unemployment* was originally issued as a separate slip but subsequent printings incorporated the corrigenda in the book. The corrigenda therefore appear as either an attached leaf or as page xxvii.

\(^\text{18}\) In his review, Redvers Opie (1935, p. 298) argued that *The Theory of Unemployment* was “seriously marred as a readable performance by slips, some corrected in a separately published corrigenda and others not”. In view of this, Opie prepared his own corrigenda listing additional to that obtainable from the publishers. Other contemporaneous reviewers, such as Paul M. Sweezy (1934) and S.E. Harris (1935), also noted additional corrections not listed in the issued Corrigenda. One recent suggestion as to why the book was poorly edited is that the publishers, Macmillan and Co., found it difficult to find an economist with the necessary skills to check through the mathematics (Leeson & Schiffman, 2010). But the correspondences from Bowley and Allen to Pigou indicate there were economists capable of conducting mathematical editing; the question remains why mathematically competent editors were not sought out before the publication of the book.

\(^\text{19}\) Also found in Pigou’s copy of *The Theory of Unemployment* (Pigou 2/3).
Switzerland) and he was “not yet fully clear” about Pigou’s work. Robertson’s brief postcard to Kahn also requests Kahn to “notify the Prof” of a mathematical slip on page 182 of *The Theory of Unemployment*. Kahn indicates to Pigou in his correspondence that Robertson would be sending his own list of misprints to Pigou at a later date. However, correspondence from Robertson to Pigou on misprints in *The Theory of Unemployment* was not located in the Pigou files at the Marshall Library archives. The end result appears to indicate that there was no mathematically competent colleague of Pigou at Cambridge able to devote the time to thoroughly check the mathematics employed in *The Theory of Unemployment* and that Pigou had requested Robertson and Kahn (and perhaps Fay) to check his book subsequent to its first printing.

An important general prefatory point to this discussion of the specific correspondence with Pigou from mathematically oriented economists is that they were primarily concerned about the ‘particular’ or the ‘wrinkle’ as modern economists sometimes say. These correspondents were not primarily concerned about the ‘general’, which, in this case, concerns the fundamental proposition that the relationship between labour and wage goods (and the associated interdependences between goods markets and factor markets through different stages of production) provides a sound basis from which a model of aggregate employment/unemployment and output can be developed. Of course, Keynes’s reaction to Pigou’s *The Theory of Unemployment* would fall within the category of a concern about the ‘general’, but the subject of his reaction to Pigou is beyond the scope of the paper and has already been

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20 Kahn’s correspondence to Pigou on *The Theory of Unemployment* partially negates a claim by Michael E. Brady (1995) that “[…] neither Kahn (nor J. Robinson) read or understood Pigou’s elasticity analysis, presented in chapters 9 and 10 of Part II of TU”.
treated elsewhere (for example, Ambrosi, 2003; Aslanbeigui, 1992; Brady, 1994; Collard, 1981; Cottrell, 1994; Leeson, 1998).

The correspondence discovered in Pigou’s copy of *The Theory of Unemployment* is reproduced in the appendices to this article, with Kahn’s correspondence reproduced as Appendix 1, Bowley’s as Appendix 2, Allen’s as Appendix 3, and Robertson’s as Appendix 4. But the genesis of these letters is also interesting.

4.1 Unsolicited Correspondence

The letter from Bowley’s appears to be the only unsolicited correspondence that Pigou received on the book, perhaps having being forwarded a copy of Pigou’s text upon its publication. In his letter to Pigou dated 30 August, 1933, Bowley indicated that:

“I have started on your book on unemployment, and as is my habit when I am interested have worked some of the mathematics independently. I have come across what I fear is a slip that may have rather serious consequences …”

And concludes his letter writing -

“I hope that you will find that I have discovered a mare’s nest”.

Bowley’s correspondence is of interest as it indicates an open, scholarly relationship with Pigou; Bowley approaching Pigou about errors and providing alternative mathematical working. Pigou would often refer to Bowley’s statistical work, citing it frequently in his own work on unemployment. This relationship was clearly reciprocal, Bowley having acknowledged Pigou in the Preface to *The Mathematical*
Groundwork of Economics: An Introductory Treatise published in 1924 for the advice and assistance which Pigou had provided Bowley in producing the book. This is of interest too in terms of Pigou’s subsequent formalisation of his unemployment theories in mathematical form, as Bowley’s treatise was one of the first to systematically express mathematically a range of economic theories developed by many notable scholars including both Marshall and Pigou and provides an early indication of Pigou’s interest in, and support of, methodological formalisation in economic theory development.

4.2 Solicited Correspondence

While Bowley’s correspondence appears to be an independent communication to Pigou after reading The Theory of Unemployment, the other four pieces of correspondence appear to be in the nature of reply to Pigou (and in Allen’s case, via Fay).

Kahn writes to Pigou in a letter dated 13 August, 1933 –

“[…] I have been through the pages in question and though I cannot pretend to be very clear about it yet, I think that your corrections [my italics] meet the case […]”.

However, Kahn goes on to identify a series of further errors, including the one identified by Robertson writing –

“Dennis is, I believe, sending you his list of misprints. I enclose a card from him”.

21 Further correspondence from Robertson was not found amongst the correspondence found in the Marshall Library archives.
Maurice Allen, who at the time was a Fellow and tutor in economics at Balliol College Oxford, writes to Fay in an undated letter –

“Herewith is the note you wanted, about Pigou”.

As Pigou was the final recipient of Allen’s correspondence, and the letter from Allen to Fay is undated, two possible scenarios arise: first, Pigou found errors in his own mathematical work and sought further assistance from Kahn (and Robertson) and Allen (via Fay) to check through specific sections of mathematical reworking. Second, Allen’s contact and correspondence via Fay may have alerted Pigou to several errors in his book after which he sought further verification from Kahn and Robertson. Bowley’s work, however, appears to have clearly been an independent discovery of errors in the first printings of Pigou’s book.

4.3 Issues that Pigou Ignored: (i) elastic at works; and (ii) time when discounting

All of the mathematical corrections that appeared in Pigou’s Corrigenda were identified by Allen, Bowley, Kahn and Robertson (see Appendix 5). Suggested mathematical re-workings by Bowley and Allen (see Appendices 2 and 3) were not incorporated as amendments in the Corrigenda but the re-workings generally indicate a difference in mathematical form between Pigou and Bowley and Allen. Bowley’s and Allen’s technical expressions are much neater highlighting Pigou’s own comment concerning his mathematical expression; Pigou refers to one of his own general formulas as “ungainly” (1933, p. 43). Two additional points of query are raised, one by Allen and the other by Bowley, that Pigou did not address via the Corrigenda.

(i) **Allen on elasticity of demand at works**

Allen is concerned by Pigou’s considerations as to the possibilities of being able to quantitatively determine the values upon which the elasticity of demand for
labour, which Pigou develops in Part II, Chapter III of *The Theory of Unemployment*, depends. Allen doubts Pigou’s logic in §7 on page 46 concerning the assignation of values for the elasticity of demand for output at works in terms of wage goods \( (E_f) \). Pigou recognised some commodities also comprise a quantity of wholesalers’, transporters’ and retailers’ services. In order to determine values for \( E_f \) Pigou introduced the elasticity of the final buyers’ demand for the commodity, \( E'_f \), and argues that as a rough approximation it could be postulated “that the proportion of the total value contributed by the cost of these services remains constant in the face of the short-period variations in consumption that follow from changes in the wage-rate”.

Calling the total value divided by the cost of distributors’ services \( k \), Pigou argued that if there are no variations in stock levels held by dealers then,

\[
E_f = \frac{1}{k} E'_f \tag{9}
\]

Allen makes what he considers the error in Pigou’s logic explicit by providing Fay the following –

Let \( p = \) selling price of commodity to consume, \( \pi = \) price of commodity at works, and \( y = \) output of commodity

\[
\frac{p}{y} \frac{dy}{dp} = E'_f
\]

\[
\frac{\pi}{y} \frac{dy}{d\pi} = E_f
\]

\[
E_f = \pi \left( \frac{1}{y} \frac{dy}{dp} \right) \frac{dy}{d\pi} = E'_f \cdot \frac{\pi}{p} \frac{dp}{d\pi}
\]

23
Allen concludes in his note to Fay that he doubted whether \( E_f = \frac{1}{k}E'_f \).

Pigou’s response to this claim concerning the logic of the determination of \( E_f \) and treatment of distributive services is unknown and remained unchanged via correction in *The Theory of Unemployment*. Pigou’s logic in this case was also disputed by both Redvers Opie (1935) and S.E. Harris (1935) in their respective reviews of *The Theory of Unemployment*. Opie repeated Allen’s doubt - “Either this is a slip or I do not understand Professor Pigou’s assumption. By that assumption it appears to be obvious that \( E_f \) equals \( E'_f \).” \(^{22}\) Pigou’s stated assumption is that there are no variations in stocks held by dealers and that, as a rough approximation, the proportion of total value contributed by the cost of distributive services remains constant during short-period variations in consumption following changes in wage-rates. Harris appears to accept, on the assumption of constant levels of stock held by dealers, that \( E_f = \frac{1}{k}E'_f \) but argues that Pigou cannot assume “even as a rough approximation” that the proportion of distributive services remains constant in short period variations in consumption following from changes in wage-rates. Harris argues that it was “well-known that there is a relative constancy of monetary return for distributive services when wages and prices vary” and hence accounted for large variations in the proportion of distributive service costs. Harris then extends this

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\(^{22}\) At the time of writing his review Opie would have been a colleague of Allen’s at Oxford and it may have been likely that discussion of Pigou’s work would have occurred.
argument to Pigou’s assumption that $m$, the relative per unit demand price of finished product to raw material (refer section 3.1 above), does not vary over short periods. Harris argues that Pigou’s argument, where the discussion of time has been postponed, “seriously violates” the facts where “the proportion of the price for final product accounted for by the receipts of farmers for raw material has varied from year to year and even from month to month since 1929” (Harris, 1935, p. 290). In this case Harris argues that there remains a difficulty (if not an impossibility) of being able to accurately correct $E_f$, the elasticity of demand for output at works in terms of wage goods, for variations in stocks which may be of prime importance in determining the effects of wage rate reductions in the short term.

Pigou may have remained unconvinced by Allen’s argument in terms of his own model assumptions (though the case for error is compelling) or it may have proved impractical to address this issue via a corrigenda listing. It is perhaps appropriate here to acknowledge the lack of clarity in *The Theory of Unemployment* in Pigou’s model and assumptions (as evident by the different responses of his readers). A possibility here may be that Pigou’s intention was to approximate an ex-post adjustment to $E_f'$ in a pragmatic way rather than a strict analytical approach. But as Opie’s and Harris’s criticisms highlight, the lack of analytical clarity of Pigou’s work served to detract from his economic argument. Harris’s critique goes somewhat further by highlighting tensions between Pigou’s assumptions concerning logical time (Pigou’s short-period analysis) and observed dynamic adjustment between industries in the face of wage rate changes. Allen’s note highlights that perhaps Pigou’s attempt to incorporate approximations of real observation of business activity occurring in historical time was immured by static analysis.
One further point may be made as to why Allen’s query concerning the relationship between $E_f$ and $E'_f$ remained unaddressed by Pigou. Pigou had a history of taking his time to address critiques of his economic logic (notable in this case was Pigou’s delayed response to Allyn Young’s identification of Pigou’s erroneous treatment of increasing returns in *Wealth and Welfare*). As Harry Johnson (1960, p. 153) recalled – “[Pigou] was unwilling to accept correction from anyone … but when finally convinced that his critic was right … he admitted it unreservedly”.

(ii) **Bowley and time when discounting**

Pigou’s problematic Chapter VIII in Part II of *The Theory of Unemployment* concerning the development of the elasticity of discounting came to be the focus of several of the book’s contemporary reviewers. Seymour Harris (1935) found errors remained in Pigou’s mathematics and conclusions; Redvers Opie (1935) noting that some paragraphs are “especial offenders”; and Paul M. Sweezy (1934) generally questioning the extension of Pigou’s (and essentially Marshall’s) definition of the short period to the economy as a whole.

Bowley identified slips in Pigou’s mathematical treatment of these issues, which were extensive, and accepted by Pigou (this is reflected in the amount of errors listed in the Corrigenda for this chapter, see Appendix 5). In addition, and perhaps most substantively, Bowley raised a theoretical question concerning Pigou’s analytical treatment of time: Having corrected the equation for the discounting of elasticity for time (by swapping positive and negative signs), Bowley writes to Pigou:

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23 On the matter of increasing and decreasing returns, Allyn Young (1913) had identified a flaw in Pigou’s analysis of industries with increasing returns and it took Pigou until the appearance of the second edition of the *Economics of Welfare* in 1924 to acknowledge his error and correct his account. Collard (1981) disputes the contention that Pigou “unreservedly” accepted all of Keynes criticisms concerning his unemployment analysis.
“I am rather perplexed about the unit in which “k” [the length of period of production] is measured; in the main formula every other quantity is an elasticity and independent of the unit, and, therefore k/e and “k” itself must be absolute numbers also. I suppose that on Page 82 “k” equals one-half; the difficulty is that “k” is of the dimension of time, and time does not explicitly enter into the other terms. It is, I feel, quite possible that what I have written is due to some misunderstanding of your terms of argument, but I thought that I ought to call your attention to my difficulty”

– Bowley letter to Pigou August 30, 1933.

Pigou in this case develops modelling to demonstrate that the real elasticity of demand for labour becomes more elastic when the average period of production increases and/or the elasticity of discounting decreases. Drawing on statistical approximations of working capital made by John Maynard Keynes and Wesley Mitchell in the United Kingdom and United States respectively, Pigou estimates the average period of production, $k$, to be about six months or a half of a year (1933, p. 82). Although Pigou’s approach is appropriate within the confines of his analytical set-up, Bowley’s observation, like Allen’s, draws attention to Pigou’s pragmatic, rather than strictly technical, use of mathematics in developing his economic argument. Bowley is not questioning the nature of Pigou’s economic argument, but questioning the consistency and robustness of adjusting the concept of elasticity, which concerns ratios of relative change which are independent of the units that the ratios are measured in, for changes in a period of time, which, in contrast, is necessarily linked to the units in which time is measured. 24 Pigou again appears to be pragmatically extending the constraints of the statical method by using

24 By accounting for time within the differential analysis and the use of $t$ subscripts to delineate dynamic changes
approximations of real time observations in the development of his logical analysis. But notwithstanding this, Pigou was obliged to explicitly state in his text what unit of time \( k \) was to be measured in. Bowley’s inference that a unit of \( k \) is given by 12 months appears to be correct.

Ambrosi (2003) discusses at length the centrality of Pigou’s short period analysis in Keynes’ critique of Pigou’s modelling of unemployment; the limitations of the “classical” method, constrained by static analysis where time was endogenous and defined by intervals in which economic quantities remained stationary. Keynes (1971-89 CW XIV, p. 238) referred to Pigou’s analysis in this regard as representing a “frozen land” economy “remote in its characteristics from all experience”. In light of this it is perhaps surprising that Bowley did not have more to say regarding the nature of the difficulties he had with Pigou’s economic analysis and treatment of time rather than the confining his comments to the technical consistency in Pigou’s accounting for the influence of time on other economic concepts.

5. Pigou’s departure from Marshall’s tradition of hiding the Mathematics

Pigou’s path from literary to mathematical economics has been relatively unexplored in the literature. In one sense Pigou’s greater use of mathematics is surprising because *The Theory of Unemployment* explicitly marked a departure by Pigou from traditions set by Alfred Marshall at Cambridge concerning the place of mathematics in the rhetoric of economic theory. Pigou’s mathematical modelling in *The Theory of Unemployment* also became a focal point of difference with Keynes in their respective analysis of unemployment. *The Theory of Unemployment* can therefore be considered not only a watershed in the development of Pigou’s own economic thought concerning unemployment, but also revealing in terms of the
philosophies and sociologies of economic knowledge that were evolving at Cambridge during this period.

But in another, broader, sense, Pigou’s greater use of mathematics is perhaps not surprising because the appearance of *The Theory of Unemployment* in 1933 coincided with the beginning of a new period of increased formalisation within the discipline of economics generally. Of course, the formalisation of economic theory has its origins in 19th Century continental Europe, with the works of masters like Antione Augustin Cournot, Leon Walras, G. B. Antonelli, Vilfredo Pareto and Enrico Barone, with elements of the continental style of formalism being progressively adopted in the UK from the late 19th century, primarily through the work of F. Y. Edgeworth, and then in the early 20th century by others including Arthur Bowley, who wrote the *The Mathematical Groundwork of Economics* (1924). But, as Mary Morgan (2012, p. 10) has pointed out, the 1930’s marked a new period of enhanced mathematical formalism in economics, identifying the important transformative role Ragnar Frisch’s 1933 mathematical model of the business cycle played during this period, describing Firsch’s “macro-dynamic system” as providing the basis for the first econometric model of a whole economy built by Jan Tinbergen in 1936. Tinbergen utilised a theory of the business cycle in mathematical form together with statistical information to derive parameters for the numbers of the equations to model the Dutch economy.25

The wider deployment and usage of mathematical models in the 1930s with models designed to facilitate the integration of empirically estimated parameters led to theory being directly related to real economic phenomena, with formal economic

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25 It is of note that Stephen Stigler (1996) identifies important benchmark works in mathematical statistics appearing in 1933 and identifies that particular year with the birth of mathematical statistics as a separate field of study (or discipline).
analysis coming to have direct relevance to both professional economists and to public policy makers. Pigou’s formalisation, however, was conceptually closer to the 19th century continental approach to economic theory, and to Edgeworth’s of the late 19th and early 20th centuries, than it was to the development of the 1930s in which enhanced formalism integrated the results of economic and econometric theory. This is not to suggest that statistics were not important to Pigou. They were, not because it meant parameters could be incorporated within a model, but because statistics provided a way of checking the relevance of a mathematical model to see if thinking along the lines suggested by the model will yield insights into the real world.

The multifarious signals offered by Pigou in the Preface to *The Theory of Unemployment* provide some indication of its intended function as a scientific object: he is studying “a simplified model of the economic world rather than the world itself in its full completeness” noting that “neither our analytic apparatus nor statistical information is at present adequate for that”; he wishes to dispense with “cotton wool” and state what he wishes to in a direct manner using mathematical exposition; he explicitly addresses his work to “students of economics” and makes strong comments as to the purposes and functions of economic analysis; he states the aim of his work is “to clarify thought, not to advocate policy” and in acknowledging the “tentative character” of his work, states further in the body of the book that it is “the method of analysis” to which he wishes to draw attention. Reasons for Pigou’s change of style may be examined by considering these signals Pigou presents to his readers as to the purpose of his book: an articulation of a particular aspect of observed economic reality concerning unemployment (ontological); as a tool of persuasion as to the validity of his knowledge claims concerning unemployment (epistemological); the linking of disparate considerations of unemployment into a connected theory
addressed to students of economics (pedagogical); and a tool in order to “clarify thought” and “break new ground” (methodological). Each of these perspectives will be considered to develop tentative reasons for Pigou’s change in expositional style. But first, how Pigou’s scientific contributions were embedded in the wider social context of the emerging discipline of economics and its attitudes towards the use of mathematics needs to be considered.

5.1 Method, Mathematics and “thought tools”

It could be argued that forms of mathematical method have been employed by human societies in matters of economy since ancient times. Mathematical technique and scientific discoveries during the scientific revolution, however, furnished the emerging discipline of political economy with new methods of thinking about economic problems. For example, William Whewell’s mathematical analysis of Ricardian economics was amongst the first in Great Britain to have introduced mathematical rigour to questions of political economy during the 19th century (Porter, 1994).

The history of mathematics at Cambridge University, however, is rather particular, with a synthetic-geometric mathematics based on Newtonian mechanics dominating mathematics at Cambridge until the mid-19th century when continental developments in the analytic method, particularly contributions by Joseph-Louis Lagrange and Pierre-Simon Laplace and other continental Europeans, began to be integrated in the Mathematical Tripos at Cambridge. The development of mathematics within the scientific communities and institutions of Europe took quite a different path. For example, Gert Schubring (2005, pp. 61-66) argues that the relationship between mathematics and science in France was forged between France’s military and education establishments during the 18th century, which lead to the
analytic method, under which abstract formal rigour is advanced in isolation from all other influences, peaking in France around the turn of the nineteenth century. Mathematicians, Gaspard Monge and Lazare Carnot, promoted the analytic method during the late 1700s as founders of the École polytechnique’s which had originally been set-up as a military educational institute. A curriculum focused on producing professionals in science, law and engineering reflected the priority placed on these professions as vestiges of, and ambitions to correct, France’s relatively weaker position and defensive capacities compared to other industrialised nations after the French revolution. The teaching of mathematics in Germanic states was impacted by the influences of religion. Lutheran territories advocated a strong role for mathematical education in schools and universities. In catholic territories, influenced by the Jesuit system of education, mathematics was a marginal subject. In contrast, mathematical training in Great Britain was part of a wider cultural tradition in collegiate curriculums where the emphasis was on providing gentlemen with a liberal education which had distinct moral undertones and was aimed at developing an intellectual elite to furnish British society with leaders such as teachers, clergymen, lawyers, statesmen and men of business (Warwick, 2003 p. 181). A mix of synthetic-geometric and analytic mathematics became part of the curriculum of the Mathematical Tripos at Cambridge after this time, but not without manoeuvring by promoters of the analytic method on one side, and promoters of the synthetic method on the other, with regard to their respective place in the mathematical tripos training (Becher, 1980). Through Whewell’s influence, however, mathematics at Cambridge remained focused on problem solving centred on the physical sciences, rather than on abstract rigor, consistent with the broader cultural traditions in England of providing a liberal education.
The cultural passage and development of mathematics in Europe provides a background to the coincident introduction of marginal analysis in economics by William Stanley Jevons (1871) in Great Britain, Léon Walras (1874) in France and Carl Menger (1971) in Germany. In Great Britain, Jevon’s *The Theory of Political Economy* laid out the theory of marginal utility in mathematical and textual form. A decade later F.Y. Edgeworth published *Mathematical Psychics* (1881) which examined further applications of the analytical mathematical method to economics. The decades immediately following Jevon’s work led to a period of dissention and debate amongst leading academics of political economy in Great Britain with regards to the relative importance of historical and analytic methods (Schabas, 1990 pp. 114-118). But coinciding with Alfred Marshall’s efforts to professionalise the discipline of economics, John Neville Keynes treatise appearing in 1890, *The Scope and Method of Political Economy* claimed an accord within the profession as to the value of the analytic method in political economy. Keynes’s view was that a plurality of method should be pursued; the problem at hand being examined defining the method most appropriate (1890, p. 23).

From this broader cultural history of mathematics in late 19\textsuperscript{th} century, and its importation into economics, it is evident that a schism arose during the late 19\textsuperscript{th} century between neoclassical theory and statistics and measurement. Porter (1994, p. 160-161) argues that the early pioneering mathematical economists in this case caused quantification and mathematization to become isolated from each other in the discipline. Whilst mathematical theory provided neutrality in economic discourse which later facilitated the professionalization of the discipline, it created a disconnect between economic knowledge and “the hubbub of political and commercial affairs”. That was the dilemma that economics faced that grew out of the analytical European
tradition in mathematics, such as Walrasian general equilibrium theory that emerged from the University of Lausanne, as well as in the economics of Jevons and Edgeworth in Britain.

The economics of Alfred Marshall, however, emerged with links to a different mathematical tradition, the Cambridge mathematical tradition, in which practical problem solving and synthesis guided abstraction. In short, the Walrasian approach to general equilibrium in Lausanne is an example of economics that emerged within a French-Swiss tradition of analytical mathematics, whereas Marshallian partial equilibrium economics emerged within the Cambridge tradition of synthetic-analytical mathematics. It is against this background, that Pigou’s attitudes to mathematics in Economics must be considered. In regard to the change in Pigou’s ideas on this matter, it is also relevant that Pigou’s ambitions for economic theory, especially the economics of the relationship between output and employment, were progressively moving closer and closer to issues related to general equilibrium, with his willingness to embrace mathematics in the formalisation of theory increasing to the point where he was prepared to publically note his difference with Marshall on the use of mathematics in economics. As Sir John Hicks would note in his correspondence with Ursula Webb during the 1930s, he thought that Pigou was indeed “…a general equilibrist […] at bottom!” (Marcuzzo & Sanfilippo, 2009, p.86).

The impact of Alfred Marshall’s attitude towards the place of mathematics in economic method and discourse upon Pigou are revealed to some extent by Pigou’s own recollections. Pigou (1952b, pp.113-9) recalls Marshall’s advice that mathematics “ought to be used sparingly”. Marshall thought that economists should be concerned with the real, rather than imaginary, world and because economic
aspects of the real world are exceedingly complex, mathematical expression becomes limited to highly simplified, artificial models. Marshall’s fear recalled by Pigou was -

“… that [economists] may develop such an affection for these models as to forget that they are only models, and bad ones at that; that we may be led to neglect important aspects of reality which cannot be worked into them; and so may get our whole picture of actual economic life distorted and wrongly proportioned.” (p. 116)

Marshall’s attitude to mathematics in economics is often famously recalled by his advice to Bowley to: (1) use mathematics as shorthand language rather than as an engine of inquiry; (2) keep to them until you have done; (3) translate into English; (4) then illustrate by examples that are important in real life; (5) burn the mathematics; (6) if you can’t succeed in 4 burn 3, the latter of which Marshall indicated to Bowley that he did often (Pigou 1953, pp. 8-9).

Various studies have provided a rich and complex picture of Marshall’s attitudes towards mathematics (Cook, 2009; Groenewegen, 1995a; Tiziano Raffaelli, Giacomo Becattini, & Dardi, 2007). From these studies a picture emerges of the relationship between Marshall’s economic thought and mathematics as having been shaped by: his experiences as a young scholar with particular interests in mathematics and the relationship he had with his father; in the course of the stringent and exacting requirements of, and mathematical traditions inherent in, the Mathematical Tripos at Cambridge from which Marshall graduated as a senior wrangler; in relation to his ambitions for professionalising the discipline of economics by using language accessible to the layperson, thereby requiring the underlying mathematical arguments to remain hidden or banished to footnotes and appendices; his innate tendencies to avoid controversy and recognise the importance of predecessors’ thought; his
concerns that economic realities required biological analogies rather than mechanical; and his recognition of the importance of institutions and history in understanding economic phenomenon. What can be clearly asserted is that Marshall’s own set of contingent circumstances shaped his attitudes as to the place of mathematics in economic science. More importantly, though his views would have undoubtedly impacted upon Pigou’s own methodological position, Pigou’s own particular contextual circumstances are pivotal in understanding his choice to depart from his teacher and mentor’s respected advice.

Pigou, unlike Marshall, did not come to the study of economics via the Mathematical Tripos and wrangler tradition. Pigou was admitted to King’s College Cambridge in 1896 after having obtained a scholarship at Harrow to study history and modern languages. He commenced his first area of study in the undivided Historical Tripos before completing the Moral Sciences Tripos in 1900 where he came under the influence of Marshall. Pigou’s path to economics was, therefore, different to several Cambridge scholars who gravitated to economics via the stringent standards of the Mathematical Tripos (including Marshall, Henry Sidgwick and later William Ernest Johnson, Arthur Berry, Alfred William Flux, Arthur Lyon Bowley, Charles Percy Sanger, and John Maynard Keynes). Pigou was, however, in no way mathematically naïve.

Pigou’s early formative education commenced at Harrow School, and although it is well known that Pigou was Head of Harrow in his senior year, and was an exceptional student (Saltmarsh & Wilkinson, 1960 p. 4), it is less well known that Pigou consistently ranked amongst the top ten students in the Mathematical part of Examinations during his schooling (Harrow School archivist, 2012). During Pigou’s first three years he achieved an overall ranking of first (Harrow School archivist,
2012). This was based on aggregate marks in the classics, mathematics and other subjects. Pigou never ranked lower in the aggregate than third. During fifth form Pigou was awarded a distinction in mathematical problems and won the prestigious Neeld Prize (a competitive essay in Mathematics). Pigou’s housemaster at the Newlands Boarding house where he stayed during term-time was Francis Edward Marshall, who was also a Mathematics teacher at the school (Harrow School archivist, 2012) and a 1st Class graduate of the Cambridge Mathematics Tripos (Vargas, 2010). So, although Pigou had not completed the Mathematical Tripos, he had, during the formative years of his education, a sound training in, and talent for, mathematics.

Gregory Moore (2005), in his review of Andrew Warwick’s (2003, p. 86) Masters of Theory: Cambridge and the Rise of Mathematical Physics, notes that toward the end of the Victorian period the Mathematical Tripos began to lose its hold on Cambridge in a broad cultural sense, and corresponded to a new generation of men entering economics from the Historical Tripos, and/or, the Moral Science Tripos. However, Pigou’s mathematical education in the public school system during Victorian Britain provides an example of the wider impacts, and cultural traditions, of the Mathematical Tripos via “wrangler nurseries” (where past wranglers became teachers in the greater public schools in Britain). Thus, although Pigou did not come to economics via the Mathematical Tripos, the wider impact of the wrangler tradition meant that Pigou was exposed to tutelage in mathematics in line with traditions which had migrated from the Mathematical Tripos to the public school system.

Pigou as a young Cambridge scholar demonstrated a willingness to consider alternative ideas and techniques and synthesis them in the process of developing his economic thought. As a Fellow at King’s and lecturer in the Economics Tripos, Pigou
incorporated mathematical analysis in his early work concerning tariffs and in *Principles and Methods of Industrial Peace* (1905) which highlights the influence, of not only of Marshall, but also of Edgeworth and Bowley upon the method Pigou employed. Pigou was influenced by the treatment of the range of indeterminateness of remuneration settlement which appeared in F.Y. Edgeworth’s *Mathematical Psychics* (1881) and had raised the possibility of using Arthur Bowley’s “statistical device of substituting an estimate of changes for one of absolute amounts” in order to calculate the normal wage of any given trade (1905, p. 62). This marked the start of Pigou’s habit of drawing upon Bowley’s statistical work and he would subsequently refer to Bowley’s statistical work in his deductive studies. Pigou was, however, an early critic of early statistical method. For example, in the course of providing advice to the Royal Commission on the Poor Laws and Relief of Distress 1905-09, Pigou presented a critique of George Udny Yule’s early regression analysis on poverty based on the impact of missing variables and issues of quantifying qualitative information (Stigler 1986, p. 356). The influence of Edgeworth and Bowley upon Pigou, although it may not have been direct, appears to be more significant in the development of his economic thought with regard to method than has been previously considered. Although Bowley had come to the study of economics via the mathematical tripos, Edgeworth, who had studied ancient and modern languages, was self-taught in economics and mathematics and was much more influenced by continental developments (Barbe, 2010, pp. 16, 109). Early in his career, Pigou also collaborated with John Maynard Keynes, another product of the Mathematical Tripos. This is evident in *Principles and Methods of Industrial Peace* (1905) but also in correspondence relating to an early collaboration concerning index numbers (Marcuzzo & Rosselli,
Another wave of broad changes occurred in mathematics originating from the studies of Continental mathematicians at the end of the 19th Century and early 20th century. This included developments in non-Euclidean geometry by Felix Klein and David Hilbert, Cantor’s development of set theory, and challenges to Newtonian mechanics arising from the development of quantum physics and thermodynamics (Weintraub 2002, pp. 23-5). The Cambridge mathematicians and philosophers, Alfred North Whitehead and Bertrand Russell, made further contributions with their own respective works and their celebrated collaborative *Principia Mathematica I-III* published in three volumes during 1910-1913. This work had ambitiously set out to define mathematical entities like numbers, in pure logic and then derive their fundamental properties (Irvine, 2010). These changes are particularly pertinent to the consideration of Pigou’s departure from Marshall’s mathematical traditions in economics. Weintraub (2002, pp. 22-23) argues that Marshall did not embrace contemporaneous developments in mathematics but rather, his mathematical thinking remained wedded to his earlier training in the Mathematical Tripos.

Pigou’s path to economics, however, highlights the general changes and shifts emerging from new developments in mathematics and science. Pigou pointedly addressed and orientated economic methods in light of these changes in his 1908 inaugural lecture *Economic Science in Relation to Practice*. Pigou refers, for example, to Russell’s *Principles of Mathematics* published in 1903 and directly considers how economic science should proceed in light of the distinctions between “pure mathematics” and “the realistic type represented by experimental physics”. Pigou (1908, pp.15) argues that economics is “concentrated upon the world known in
experience, and in no wise extends to the commercial doings of a community of angels” and that it is “the realistic and not the pure science that will constitute the object of our search”. But countering this is a measured consideration of the benefits of a plurality of method and the relationship between the two – “It is only by reference to […] general rules that the forecasts, which practice needs, are rendered possible” (Pigou 1908, p. 17). Pigou identifies three functions of economic science. First, economics can be employed as a form of logical argument which can furnish useful information to check misguidance in government. Second, economics can furnish positive information of a qualitative nature in terms of identifying relationships between causes and effects. Third, economics can furnish quantitative analysis of the amount of relation between causes and effects. Pigou then identifies areas where further progress was required in economic methods. Observing the differences between dynamics and economics, Pigou identifies the great technical difficulties that remained in economics in being able to state economic laws in an exact form because of the multiplicity and varying nature of the constants involved. The corollary being that inferences from economic laws in particular cases could not, during the time of Pigou’s address, “be thrown into any quantitatively precise form”. Pigou acknowledges that although “great progress” had been made in economic methods, there remained “a great gap to be filled” and firmly makes the statement that in regard to such progress he stood “in the place of one who has been and is the leader”.

Significantly, Pigou revised his opening chapter of Wealth and Welfare in The Economics of Welfare in 1920 to include his 1908 observations. Exegesis of this chapter reveals that it has been rewritten by Pigou by a nearly direct incorporation of his observations concerning economic methods from his inaugural lecture of 1908.
together with several pertinent observations about the impacts of war. The impact of
the First World War most certainly led to a general realignment of strategies and
narratives in intellectual communities. For example, in the period immediately after
the First World War the philosophy of Bertrand Russell, Ludwig Wittgenstein and
Ernst Mach became influential and would later in that decade influence the logical
positivist movement originating in Vienna. Pigou cites both Russell’s and
Whitehead’s respective texts in mathematics in his work after the war signifying the
influence of these scholars upon the evolution of Pigou’s own mathematical
considerations pertaining to economic theory (for example, Pigou 1920 p.5, 1932
p.10, 1941 p.279).

During the mid-1920s Pigou also began collaborating and encouraging the
work of the young Cambridge mathematician and philosopher, Frank Plumpton Ramsey. Ramsey, remembered by Keynes (1933) “as one of the
brightest minds of our generation”, was also actively discussing economics with
Keynes and Piero Sraffa and philosophy with Wittgenstein; Ramsey having been
nominated Wittgenstein’s supervisor for the submission of his previous work
Tractatus Logico-Philosophicus published in 1922 for the award of Ph.D. during
1929.26 Ramsey had provided Pigou with assistance in: Pigou’s 1926 “A
Contribution to the Theory of Credit”; his previously cited article appearing in 1927
on unemployment, elements of which Pigou examined further in The Theory of
Unemployment; with revisions to the third edition of The Economics of Welfare
appearing in 1928; and in the development of Pigou’s treatise on public finance A
Study in Public Finance (1928a). Pigou and Keynes had both influenced and

26 Wittgenstein was awarded a Ph.D. from Cambridge for his thesis Tractatus in 1929; G.E. Moore and
Bertrand Russell were the examiners. See Monk (1990, pp. 271-273) for an account of the nature of
Wittgenstein’s award and subsequent pecuniary award from Trinity College after this occasion.
encouraged Ramsey’s own ground-breaking mathematical papers on economic subjects, *A Contribution to the Theory of Taxation* (1927) and *A Mathematical Theory of Saving* (1928).\(^{27}\)

In *Industrial Fluctuations* (1927a) as well as his article “Wage Policy and Unemployment” (1927b), Pigou vigorously warned that the statistical correlations made between real wage rates and unemployment by French Economist Jacques Rueff during the 1920s “must not be treated as an inductive proof of the conclusion set out”, but should “rest upon the general considerations there advanced in support of it”.\(^{28}\) In 1929, in his Sidney Ball Lecture at the University of Oxford in May, Pigou again outlined his position on method in economics. Responding to Sir Josiah Stamp’s claim that the analytic method had reached the limit of its usefulness, Pigou strongly argued the case for, and echoed John Neville Keynes earlier call for, a plurality of method – “With different problems and with different sets of data, different detailed methods are appropriate” (1931, p. 2). Distinguishing between tool-makers and tool-users and between public (economic theories) and private (intuition) tools, Pigou argued that economic tools, unlike the tools of physics and biology, are more like “keystones” than “elaborated buildings”. As such the economist’s work is piecemeal, examining particular parts and aspects of economic life. Pigou again highlighted the technical difficulties associated with the then growing number statistical studies, the chief being fallacies in omissions of casual variables and

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27 See Duarte (2007) for a broader account of Ramsey’s intellectual interactions at Cambridge during this period.
28 Jacques Rueff’s paper “Variations in Unemployment in England” first appeared in December, 1925 in a French academic journal explaining joblessness as a function of the relative price of labour. This article appeared six months before Irving Fisher’s paper explaining unemployment as a function of the rate of price inflation. Rueff’s paper, however, gained notoriety in Great Britain after it was later reproduced first in the *Financial Times* during 1926 General Strike, and again in the *London Times* in 1931 during the period when the May Report’s recommendation of large-scale public sector wage cuts and large cuts in public spending (notably on payments to the unemployed) in order to avoid a budget deficit were released.
fallacies in the logic of probability. Pigou did not believe that the technical issues in statistical analysis were insuperable but, indicated in his address that much more work needed to be done. Pigou summarised his argument thus – “statistical correlations […] can give invaluable indications as to where our economic tools may be usefully employed; they can also confirm and corroborate; but they do not and cannot warrant us in leaving the tools behind” (1931, p. 13). Pigou’s other important observation in his address concerned the epistemological relationship between economists, statesmen and politicians and the public. Pigou argued that economics would not render its full service “unless the nature of the subject-matter with which its experts deal is understood, not only by their colleagues, but also in some measure by the general body of educated men”.

In the period leading up to his writing *The Theory of Unemployment*, Pigou had not only observed institutional changes affecting economic activity, but also broad changes in the sciences which had impacted method within his own discipline. Pigou also observed a change in the relationships between professional economists, statesmen and the public, coincident with broader cultural changes which had occurred in labour and labour relations, from the impacts of World War I, and structural changes impacting Britain’s real economy. Because of these changes, the subject matter of Pigou’s economic analysis had changed from that which was pressing in Marshall’s time. The “tools” available to economists had also changed. Pigou’s departure from the Marshallian tradition concerning mathematics can, therefore, be considered not a discontinuity per se, but rather a necessity of cultural evolutionary change. By 1953, Pigou could not think that Marshall “would have condemned a mathematically minded man [like] Frank Ramsey […] for tackling real economic problems with the help of mathematical machinery” (Pigou, 1953 p. 11).
Pigou retained Marshall’s cautiousness as to the place in mathematics in economics by considering mathematics as a “thought tool”, and just one tool amongst many in an economist’s toolbox, rather than considering mathematical modelling as an opportunity to incorporate statistically estimated parameters to present a mechanically determined result. Pigou considered the importance of methodological aspects of economics from his early career, but changed his method of analysis in line with his own precepts which he himself had set, and which had earlier been called for by John Neville Keynes; a plurality in method. Pigou presented his study of unemployment making “use without disguise of whatever tools have appeared to me, in different parts of the analysis, to be helpful”. Harris described the tools and manner of analysis adopted by Pigou as constituting “a great contribution” and noted its ground-breaking aspects commenting that Pigou had “brought attention to methods of analysis that promise solutions to problems hitherto insoluble”. (1934, p. 322). The Theory of Unemployment liberally utilised mathematical modelling, but there were attempts by Pigou to synthetically relate this modelling to the real world, and in parts of the text, he employed intuition. Although Pigou’s reviewers would castigate the use of his “guesses”, Pigou employed deductive means which Paul Douglas (1934, pp. xvii-xviii) would later acknowledged as providing some corroboration to his own statistical studies.29

5.2 Mathematics as a requirement to express economic complexities

Pigou’s extensive use of mathematics in The Theory of Unemployment may be viewed as a requirement arising from the level of difficulty he encountered in

29 Paul H. Douglas (1934, p. xviii) found Pigou’s deducted elasticities for labour as a whole during booms too high, but Pigou’s (1933, p. 98) estimates for periods of depression at not less than -3.0 comparable to his own empirical studies for “normal” elasticities concluding that “Pigou’s work therefore lends some corroborations to my “normal” results”. Robert M. Solow (1980, p. 6) also provides a consideration of Pigou’s “elaborate” and “careful” short-run elasticity of demand for labour but generally concludes that Pigou’s approximated elasticities “are way too high”.
analysing unemployment as an aspect of a complex economic reality. First, the increase in the degree of interdependence being investigated in micro markets which entailed the examination of final demand, demand for raw materials and demand at works was difficult, if not impossible, to do in a purely literary manner. Second, Pigou’s building of a macro-model of aggregate employment and mathematics appears to have become necessary in order to take into account interdependencies between the wage good and the non-wage good sectors. In short, Pigou was tending to incorporate themes more typically considered in general equilibrium. Pigou remained, however, very aware that what he was studying was “a simplified model of the economic world rather than the world itself in its full completeness” noting that “neither our analytic apparatus nor statistical information is a present adequate for that” (1933, p. vi).

5.3 Mathematics as a form of persuasion of epistemological claims

In his address in 1929 on “The Function of Economic Analysis”, Pigou (1931) makes several observations about epistemic relationships between economists, statesmen and the general public. He considers the time-lag “between the attainment of knowledge in economic affairs and its entry into the halls of authority”, estimating that this lag may be 30 to 50 years long, the chief reason being “that the effects which a given line of policy will produce often depend in large measure on the degree of economic knowledge possessed by the general body of the public”. In an article first appearing in 1941, “Newspaper Reviewers, Economics and Mathematics”, Pigou (1952b) has something further to say specifically about epistemic relationships between economists and the general public and the form of publication in which economic knowledge is presented. Pigou makes the observation that for economists (students of economics) and the general public, these forms of publications will differ
because of the technical language which economists use, including mathematical symbols.

Pigou’s observations echo the philosophical writings of Ludwig Fleck’s (1935), a “classical” figure both of epistemology and the historical sociology of science. Fleck observed a tripartite social structure in knowledge production consisting of elite specialists, general experts and non-experts. Knowledge production emanated from specialists via distinct forms of transformative communication: specialists introduced their ideas in journals; general experts used vademecums; and non-experts had access to text of ‘popular science’. Feedback loops develop between the members of this tripartite social structure: in the course of knowledge production, specialist detect signals of resistance and engage in communicative acts to persuade general experts; specialist and general experts then strive for public recognition of their results as fact and scientific truths; and the loop is closed as all become subject to systems of education which take these facts and truths as accepted knowledge.

Pigou’s change of style from literary to technical language can in part be understood by the epistemic framework presented by Fleck. During the height of the depression, economists such as Pigou detected ‘signals of resistance’ from general experts and non-economists via professional debate, newspaper columns, and general demonstrations. These communicative acts had culminated in Britain in the Macmillan Committee Hearings which revealed discord amongst economists as to the root causes of unemployment. Acting on these signals of resistance, Pigou wrote and addressed *The Theory of Unemployment* to “students of economics” (general experts). The language used was technical and mathematical because Pigou differed from Marshall by differentiating modes of communication between experts and non-experts.
as means of persuasion of his knowledge claims. Pigou “discarded cotton wool” to facilitate his economic discussion and presentation of his knowledge claims to economists. Pigou (1952b [1941], p. 118) would later remark – “one of the great advantages of the use of symbols is that with them we cannot, as in language we so easily may, be ambiguous!” Although, it must be conceded that the rhetoric that Pigou employed in *The Theory of Unemployment*, both mathematical and prose, did lead to ambiguities in his work, which would later be highlighted by Keynes’s and Pigou’s contemporaneous reviewers.

5.4 Pedagogical Leadership

Pigou’s choice of mathematical exposition in *The Theory of Unemployment* may also be seen as a form of pedagogical leadership aimed at the profession of economics. Pigou presented a manner of analysis to “break new ground”, to bring to the attention of his audience “students of economics” a method of analysis. Pigou may have presented his theory of unemployment utilising a heightened use of mathematics, as a form of instruction to the economics profession that it might be explored, emulated and taught. As Pigou (1952b [1941], p 117) would later argue – “Conversation is fostered and knowledge advanced if Hindus are allowed to talk to one another in Hindustani”. That Pigou considered leadership an integral part of his role as Professor of Political Economy at Cambridge is clearly articulated in his 1908 address upon taking that Chair. Pigou stated very clearly that he stood “in the place of

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Mary Morgan (2001, p. 37) observes the peculiarly reflexive dynamic that the discipline of economics faces: dynamic and chaotic change in human activity exerts a strong influence on the pattern of economics; in response economists develop methods and tools which may subsequently be used to engineer interventions in the economy; this engenders new economic “events” which subsequently have to be reckoned with by new generations of economists. Fleck explicitly, and Pigou implicitly, observe this dynamic which can be understood by the modern conception of the process of reflexive dynamics, a phenomenon which has attracted increasing attention from scholars since the mid-20th century. Steier (1991) describes this process, arising from the interaction between human thought systems and material and social environments, as circular and unfolding in time like a spiral. See also Mead (1962) and Beck et al (1994).
one who has been and is the leader”. Pigou’s support for mathematics in theory is both clear and unequivocally stated in the preface to *The Theory of Unemployment* (1933, p. vi), and his importance to advancing formalism in economics was not lost upon his reviewers, with Redvers Opie (1935, p. 289) noting that “the great weight of Professor Pigou has been thrown on the side of making all serious economists into minor mathematicians”.

The impact of Pigou’s 1933 work upon the general direction of method in the profession has only recently been explored in the history of economic thought by Michael Ambrosi (2003) and Michael E. Brady (1995). Ambrosi and Brady have both highlighted John Maynard Keynes’s study of unemployment in *The General Theory* as framed upon the mathematical form of analysis that was in some way founded on Pigou’s *The Theory of Unemployment*. Takami (2011b) considers Pigou’s role in the ensuing critical debates on unemployment and the development of macro-economic modelling after the appearance of Keynes’s *The General Theory*, arguing that there was a distinct shift in theoretical debate appearing in *The Economic Journal* which increasingly saw argument presented in mathematical and modelling form. Pigou’s attempt to “clarify thought” by promoting the use of mathematics in this regard might be considered successful. However, Pigou’s success was also limited as many of the responses to his book focused on its technical failings reflected in part by the substantial corrigenda produced by both Pigou’s publishers and reviewers of the book. The reviewers of *The Theory of Unemployment* expressed concerns that although Pigou often underlined the abstract nature of his models in *The Theory of Unemployment*, he often went on to apply abstract results obtained from his analysis to actual economic conditions often by relying on intuitive guesses (Harris, 1935, p.

6. Conclusion

Pigou spent a good part of his working life studying economic phenomenon in order to improve the human condition. As an economist at the height of the great depression, Pigou attempted to make an original contribution towards understanding mass unemployment and to find effective remedies to ameliorate it. A wider consideration of Pigou’s economic thought present manifold purpose for his change to mathematical exposition and central to this was Pigou’s conception of mathematics and modelling as “thought tools”. In this regard mathematics was but one of the many tools available in the economist’s “toolbox” for use to analyse economic problems. Literary theory, geometric theory, statistics and intuition also resided in this toolbox.

Pigou, taught by Marshall whose own toolbox had been shaped by the peculiarities of the Mathematical Tripos at Cambridge, had incorporated tools emerging from evolving scientific advances and incorporated these advances in his own theory development as new and unexpected economic phenomenon emerged in

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31 Although an alternative consideration to this critique is the possibility that Pigou was, in many instances throughout the book, seeking to signpost to his audience avenues for the development of statistical analysis. An example of this appears on page 45 in the development of his elasticity of demand for labour at the micro level. As Pigou builds his analysis, he considers the possibilities of obtaining data that would enable the quantitative determination of the value of $E_d$. 

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the early 20th century. The mathematics employed by Pigou in *The Theory of Unemployment* bore similarities to the 19th century continental tradition in analytical mathematics. Pigou, however, remained steadfast to the Marshallian tradition whereby theory (mode of thought) and use of statistics (considering the limits and relevance of such a mode of thought) were practically oriented and not mechanical. In this context, Pigou can in no way be considered as embracing the emerging formalism during the early 1930s in which mathematical models were intended to incorporate econometric ideas and parameters which moved irreconcilably beyond Marshall’s tradition. This was the path which Pigou did not take.

*The Theory of Unemployment* was deficient in many respects, and although Pigou recognised Marshall’s concerns as to the use of mathematics in economic theory, he pragmatically argued that the use of modelling in a complex world becomes essential to isolate certain elements of the real world in order to advance economic thought; and that if is remembered that the use of mathematics “is a second-rate affair, prolegomena to economics, not economics itself, the ballistics of an imaginary vacuum, not real ballistics” (Pigou, 1952b [1941] p.116) then the dangers that Marshall feared would be safeguarded against. But Pigou’s use of mathematics had served the purpose of defining a complex problem, identifying key elements in the analysis of unemployment, and a method to examine their interdependencies. Pigou was aware of the limitations of his analysis but he sought to bring attention to the method of analysis employed (1933, p. 88). But he was unable to do so in an error-free and unambiguous way, leaving him open to criticism by other mathematically oriented economists. But, notwithstanding its many mathematical errors and inelegancies, this book provided a seminal and definitive treatment of the
elasticity of demand for aggregate unemployment and served to initiate debate in high theory of unemployment among competing schools of thought.

The correspondence from Bowley, Allen (via Fay), Kahn and Robertson did not really broach the fundamental and macroeconomics issues in Pigou’s *The Theory of Unemployment* that caused genuine confusion, and debate, among economic theorists after the publication of the book. Rather, the issues were largely in relation to Pigou’s use of mathematics to analyse nuances of the labour market, not challenging the fundamental economic approach to theorising about economic relationships in aggregate by building a theory around wage goods, labour and interdependencies. Harris (1935, pp. 323-3) found one of Pigou’s great services in writing *The Theory of Unemployment* had been to isolated “the variables requiring consideration for a concrete meaning to the concept of real elasticity of demand for labor”. The setting out of his model, though found to be deficient in many respects, had provided an avenue for economists to test for “completeness and simplicity of presentation” via the use of mathematics.

Pigou’s interest in the changing methods in his discipline endured as the formalisation of economics continued to advance. In correspondence during the 1950s with the British economist Richard Stone (King’s College archives JNRS/3/1/102), an excerpt of which appears below, Pigou acknowledges with interest Stone’s recent published work and light-heartedly recalls his own use of mathematics during the course of his career. Noting the methodological advances which had occurred in the economics profession, especially developments in Stone’s area of statistical analysis, Pigou laments his own diminished skills and, with humour, wonders if economics was at risk of becoming a branch of mathematics.
Dear Stone,

“Many thanks for your horror whose companion I see is in the *EJ* [Economic Journal]. It is *possible* though not likely, that I might eventually understand it! A hundred years ago, when I was still alive, I was looked at askance for occasionally putting a little algebra in a footnote. Now, to judge from the journals, economics is becoming a branch of mathematics – which, so far as I ever knew any, I have now completely forgotten! Alas for “progress”! I feel like St John, “like a sea-jelly” left a-strand on Patmos.”

*Excerpt of letter from A.C. Pigou to Richard Stone, Kings College Archives (JNRA/3/1/102)*
Appendix 1: Kahn’s reproduced correspondence

[Letter from R.F. Kahn to Pigou dated 13-8-33]

King’s College
Cambridge
13-8-33

Dear Professor,

I am afraid that if I am to going to get off for a few days in Switzerland, which in any case is going to be difficult, I shall have to defer a thorough reading of your book until some later time. But I have been through the pages in question and though I cannot pretend to be very clear about it yet, I think that your corrections meet the case except that on p. 81 you want to read:

\[ \pm \frac{k}{e} \text{ for } \pm \frac{k}{e} \]

\[ \pm \frac{q}{e} \text{ for } \pm \frac{q}{e} \]

\[ \pm \frac{x}{e} \text{ for } \pm \frac{x}{e} \]

and at one point in the last formula \( q \) for \( k \)

Furthermore I feel rather uncertain about p.86 line 26. Should it possibly be that \( \Delta\ y \) and \( e \) are both negative? (u.p. 85 line 2) If \( e \) is positive I am not sure that the rest follows.

Dennis is, I believe, sending you his list of misprints. I enclose a card from him, as I cannot quite see whether it is a g.p. or not. (It is of course right if it is g.p.).

Yours sincerely,

R.F. Kahn

[attachment to letter]

Theory of Unemployment – Misprints

p. 49, n.1. Bracket has dropped our round (q-w)

p. 102, l. 16. Read \( \frac{W - K}{W} \cdot \frac{Q + WX}{Q + (W - K)X} \)

p. 103 lines 3-5. For \( \frac{dx}{x} \) outside bracket read \( \frac{1}{x} \)

p. 200, last line but 2, and p. 201, line 1, For rth read lth.

p. 219, note, line 8 from end, for smaller read larger

p. 232, Text, Line 11, for Viii now ix

p. 302, Is last sentence on §1 right? If so, has it any meaning on what follows?

P. 214, note 2.4 for ‘to’ read ‘then’

Preface prii for Denis read Dennis!

[In Pigou’s handwriting at bottom of page]

\[ \left\{ 1 - \left( \frac{100}{100 + p_x} \right)^n \right\} \]

182 [Pigou’s underlining]
Appendix 2: Bowley’s reproduced correspondence

[Letter to Pigou from Bowley]

Park Avenue
Harpenden
Herts

August 30 1933

Dear Pigou,

I have started on your book on Unemployment, and as is my habit when I am interested have worked some of the mathematics independently. I have come across what I fear is a slip that may have rather serious consequences on Page 79; in the equation after the words “It follows that” the sign on the right-hand side ought, I think, to be reversed. The effect of this is to change the sign of the terms containing “e” in the principal equation on Page 81. If this is true paragraph 7 needs a good deal of amendment, but I think that the last line should read on your formula “make for an increase in Ed”, while when the formula is amended this line is correct as it stands if the absolute value of Ed is meant; thus the remarks on Page 83 that the relations can be seen a priory are in accordance with the revised version. I enclose my working of pages 79 to 83.

I am rather perplexed about the unit in which “k” is measured; in the main formula every other quantity is an elasticity and independent of the unit, and, therefore k/e and “k” itself must be absolute numbers also. I suppose that on Page 83 “k” equals one-half; the difficulty is that “k” is of the dimension of time, and time does not explicitly enter into the other terms.

It is, I feel, quite possible that what I have written is due to some misunderstanding of your terms or argument, but I thought that I ought to call your attention to my difficulty.

Also at the top of Page 84 surely the last expression should be inverted. $kDy / Dx,y / y \cdot 1 / \varepsilon$

I have not considered whether any change is suggested in the latter part of Page 85.

I enclose also an alternative working of Pages 43-4 and Pages 94-5.

You are at liberty to make any use of this communication that you please. I hope you will find that I have discovered a mare’s nest.

Yours sincerely,

Arthur L. Bowley
\[ \{f(x)\}^k \phi(q) = w \quad \text{where} \quad \phi(q) = \frac{dF(q)}{dq}, q = \frac{x}{w} \]

\[ k \log f(x) + \log \phi(q) = \log w \quad \text{(1)} \]

\[ E_d = \frac{w}{q} \frac{dq}{dw} \quad \text{write} \ E_r \quad \text{for value of} \ E_d \quad \text{when} \ f(x) \quad \text{is constant and differentiate} \]

\[ 0 + \frac{d \log \phi(q)}{dq} \frac{dq}{dx} = \frac{1}{w} \frac{dw}{dx} = \frac{1}{q} \frac{q}{w} \frac{dw}{dx} \]

\[ \therefore \frac{d \log \phi(q)}{dq} = \frac{1}{q} \frac{dw}{dq} = \frac{1}{qE_r} \]

Return to (1) and differentiate

\[ k \frac{1}{f(x)} \frac{df(x)}{dq} + \frac{d \log \phi(q)}{dq} \frac{dq}{dx} = \frac{1}{w} \frac{dw}{dx} \]

\[ \frac{k}{x} \frac{1}{qE_r} \frac{dq}{dx} - \frac{1}{w} \frac{dw}{dx} = 0 \]

Write \( e = \frac{f(x)}{x \frac{df(x)}{dx}} \). But since \( \log q = \log x - \log w \),

\[ \frac{1}{x} \frac{1}{q} \frac{dq}{dx} - \frac{1}{w} \frac{dw}{dx} = 0 \]

\[ \therefore E_d = \frac{1 - \frac{k}{E_r}}{\frac{1}{k} + \frac{1}{e}} \quad E_d \rightarrow E_r \quad \text{as} \ e \rightarrow \infty \]
Take the amended formula
\[ E_d = \frac{1 - \frac{k}{e}}{1 + \frac{k}{e}} = \frac{1 - \frac{k}{e}}{\frac{1}{E_r} + \frac{k}{E_r}} \] where \( E_\rho \) is +ve

\[ E_d \] is negative if \( \frac{k}{e} \) is not between 1 and \( E_\rho \) and always when \( e \) is -ve

\( E_d \) is positive if \( e \) is positive and \( 1 < \frac{k}{e} < E_\rho \)

\[ E_d + 1 = \frac{1 - E_\rho}{\frac{k}{e} - E_\rho} \] is negative if \( E_\rho \) is between 1 and \( \frac{k}{e} \) - if \( e \) is negative if \( E_\rho < 1 \)

\[ E_d + 1 = \frac{1 - E_\rho}{\frac{k}{e} - E_\rho} \] is positive if \( e \) is negative and \( E_\rho > 1 \)

or if \( e \) is positive and \( E_\rho \) not between 1 and \( \frac{k}{e} \)

If \( E_d \) is positive, \( E_d \) decreases with \( e \), since \( 1 - E_d \) is negative and \( e \) is positive as above

If \( E_d \) is negative \( -E_d = E_d' = 1 + \frac{E_\rho - 1}{\frac{k}{e} - E_\rho} \)

\[ \frac{dE_d'}{de} = \frac{(E_\rho - 1)\frac{k}{e^2}}{\left(\frac{k}{e} - E_\rho\right)^2} \]

\( E_d' \) increases as \( e \) increases when \( E_\rho > 1 \), \( (-E_r) < 1 \)

\( E_d' \) decreases as \( e \) increases when \( E_\rho < 1 \), \( (-E_r) > 1 \)

This last line agrees with the statement in last line of p82 et seq. That statement appears to be erroneous from the unamended formula for there -

\[ -E_d = 1 + \frac{1}{\frac{k}{e} - E_\rho} \]

if \( (-E_r) > 1 \), \( 1 + \frac{1}{E_r} \) is positive (e.g. when \( E_r = 2 \)) and \( -E_d \) increases with \( e \)
pp. 43-4 Alternative setting

x units of labour for y units of processing

\( y = \phi(x) \)

\( g(y) \) demand price for finished goods

\( s(y) \) supply price of raw material

Write \( \rho(y) = g(u) - s(y) \)

Then wage rate \( = w(x) = \rho(y) \phi'(x) \)

Elasticity \( \frac{1}{\eta} = \frac{x\phi''(x)}{\phi'(x)}, \frac{1}{E_f} = \frac{yg'(y)}{gy}, \frac{1}{E_s} = \frac{ys'(y)}{sy} \)

\[ \frac{1}{E_d} = \frac{xw'(x)}{w(x)} = x\left(\frac{x\phi''(x) + \frac{\rho'(y)}{\phi'(x)} dy}{\frac{\rho(y)}{dx}}\right) \]

\[ \frac{1}{x} \left( \frac{1}{E_d} - \frac{1}{\eta} \right) \frac{1}{\phi'(x)} \frac{\rho'(y)}{\rho(y)} \]

Now write \( g(y) = ms(y) \)

\( \rho'(y) = g'(y) - s'(y) = \frac{1}{y} \left( \frac{g(y)}{E_f} - \frac{s(y)}{E_s} \right) \)

and \( \frac{1}{E_d} = \frac{1}{\eta} + \frac{x\phi'(x)}{\phi(x)(m-1)} \left( \frac{m}{E_f} - \frac{1}{E_s} \right) \)
\( w = F'(x) \) wage rate
\( \phi(x) = x + y' \) number of wage earners
\( \phi(x).F'(x) = \) wage bill = \( F(x) - K - (A - \phi(x))r \)
Differentiate -
\( \phi'(x).F'(x) + \phi(x).F''(x) = F'(x) + r \cdot \phi'(x) \)
Substitute - for \( \phi'(x) \)
\[
E_r = \frac{\phi'(x)}{\phi(x)} \cdot \frac{F'(x)}{F^*(x)} - 1 = \frac{F'(x)}{\phi(x).F^*(x)} \cdot \frac{F'(x) - \phi(x).F^*(x)}{F'(x) - r}
\]
\[
= \frac{w}{w - r} \left( \frac{1}{\phi(x)} \cdot \frac{F'(x)}{F^*(x)} - 1 \right) = \eta \cdot \frac{x}{x + y} \left( \frac{w}{w - r} \right) - \frac{w}{w - r}
\]
Since, \( \eta = \frac{F'(x)}{F^*(x)} \)

pp. 103

Write \( L = \frac{\psi}{F} \cdot F' \) and \( \frac{1}{E_m} = x \frac{L'}{L} \)
\( FL = \psi F' \)
Differentiate -
\( \log F + \log L = \log \psi + \log F' \)
\[
x \frac{F'}{F} + x \frac{L'}{L} = x \frac{\psi'}{\psi} + \frac{F''}{F}
\]
\[
\therefore \frac{1}{E_m} = \frac{1}{E_r} + x \frac{\psi'}{\psi} - x \cdot \frac{F'}{F}
\]
Appendix 3: Allen’s reproduced correspondence

[Letter to Fay from Maurice Allen re Pigou]

Saturday.

Dear Fay,

Hereewith is the note you wanted, - about Pigou -. The references are

(i) p.79, \(- k \cdot \frac{x \cdot f'(x)}{f(x)} \cdot \frac{dx}{dw} = etc\)

(ii) p.81 \(E_d = \frac{1 - \frac{k}{e}}{\frac{1}{k} + \frac{k}{e}}\), not \(- + -\)

(iii) On p.46, I doubt whether - \(E_f = \frac{1}{k} \cdot E'_f\)

Yours,

Maurice Allen
Attached workings: [by Maurice Allen]

p.78 §3.

\[ w = \text{real rate of wages} \]
\[ x = \text{total real wages} \]
\[ F\left(\frac{x}{w}\right) = \text{total real value of output} \]
\[ i = \text{interest rate} \]
\[ k = \text{period of production} \]

Write \[ \frac{1}{1+i} = f(x) \]

Then \[ \left[ f(x) \right]^{\frac{dF}{dw}} = w \]

\[ \therefore \frac{d}{dw} \left[ f(x) \right] \cdot \frac{1}{w} \frac{dF}{dw} \left( \frac{x}{w} \right) = 0 \]

i.e. \[ k \left[ f(x) \right]^{-1} f'(x) \cdot \frac{1}{w} \frac{dF}{dw} \left( \frac{x}{w} \right) - \left[ f(x) \right]^{\frac{dF}{dw}} \cdot \frac{1}{w^2} \cdot \frac{dF}{dw} \left( \frac{x}{w} \right) + \left[ f(x) \right]^{\frac{d^2F}{dw}^2} \cdot \frac{1}{w} \cdot \frac{d^2F}{dw} \left( \frac{x}{w} \right) \cdot \frac{d}{dw} \left( \frac{x}{w} \right) = 0 \]

\[ \therefore k \cdot f'(x) \cdot \frac{d}{dw} \left( \frac{x}{w} \right) - \frac{1}{w} \left( \frac{d^2F}{dw} \left( \frac{x}{w} \right) \cdot \frac{d^2F}{dw} \left( \frac{x}{w} \right) \right) \cdot \frac{d}{dw} \left( \frac{x}{w} \right) = 0 \]

or, \[ k \cdot f'(x) \cdot \frac{d}{dw} \left( \frac{x}{w} \right) - \frac{1}{w} \left( \frac{d^2F}{dw} \left( \frac{x}{w} \right) \cdot \frac{d^2F}{dw} \left( \frac{x}{w} \right) \right) \cdot \frac{d}{dw} \left( \frac{x}{w} \right) = 0 \] ...(A)
Now write (i) \( f(x) = e \); (ii) \( \frac{d\left(\frac{x}{w}\right)}{dw} = E_w \); ss that \( \frac{d\left(\frac{x}{w}\right)}{dw} = \frac{x}{w} \cdot E_w \), and \( \frac{dx}{dw}[E_d + 1] \)

Then (A) may be written as,

\[
k \cdot \frac{1}{e} \cdot \frac{dx}{dw} = x \left[ \frac{1}{w} - \frac{d\left(\frac{x}{w}\right)^2}{d\left(\frac{x}{w}\right)} + \frac{d\left(\frac{x}{w}\right)}{d\left(\frac{x}{w}\right)} \right]
\]

If \( \frac{1}{e} = 0 \), \( E_d = \frac{d\left(\frac{x}{w}\right)^2}{d\left(\frac{x}{w}\right)} \), by definition, \( E_w \)

\[
(A) \text{ now becomes } k \cdot \frac{1}{e} \cdot \frac{x}{w}[E_d] = x \left[ \frac{1}{w} - \frac{1}{E_w} \cdot \frac{1}{E_d} \right]
\]

Whence \( E_d \left[ \frac{k}{e} + \frac{1}{E_w} \right] = 1 - \frac{k}{e} \)

\[
E_d = \frac{1 - \frac{k}{e}}{\frac{1}{E_w} + \frac{k}{e}}
\]

\[
= \frac{1 - \frac{k}{e}}{\frac{1}{E_w} + \frac{k}{e}}
\]
Let $p =$ selling price of commodity to consumer
$\pi =$ price of commodity at works
$y =$ output of commodity

\[
\frac{p}{y} \cdot \frac{dy}{dp} = E_f', \quad \frac{\pi}{y} \cdot \frac{dy}{d\pi} = E_f
\]

\[
E_f = \pi \cdot \left( \frac{1}{y} \cdot \frac{dy}{dp} \right) \cdot \frac{dy}{d\pi}
\]

\[
= E_f' \cdot \frac{\pi}{p} \cdot \frac{dp}{d\pi}
\]

(1) If $\pi = p \left(1 - \frac{1}{k} \right)$, then $\frac{\pi}{p} \cdot \frac{dp}{d\pi} = 1$

\[
E_f = E_f'
\]

(2) If $\frac{\pi}{p} \cdot \frac{dp}{d\pi} = 1$, then $\frac{dp}{p} = \frac{1}{p} \cdot \frac{d\pi}{\pi}$

w(hence) $p = C \pi^{\frac{1}{k}}$
Appendix 4: Robertson’s reproduced correspondence

[Note from D.H. Robertson address to R.F. Kahn]

Theory of Unemployment, p. 182

Shouldn’t the expression at the top read

\[
\frac{p_1}{p_2} \left( \frac{100 + p_1}{100 + p_2} \right)^2 \cdot \left\{ 1 - \left( \frac{100}{100 + p_2} \right)^n \right\} \div \left\{ 1 - \left( \frac{100}{100 + p_1} \right)^n \right\}
\]

(The sum of a g.p is \( \frac{a(1-r^n)}{1-r} \) not \( \frac{a(1-r)^n}{1-r} \))

If I am right, will you notify the Prof?
### Appendix 5: Comparison of The Theory of Unemployment’s Corrigenda and correspondence

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<th>The Theory of Unemployment's Corrigenda</th>
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<tr>
<td>Remained uncorrected</td>
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<tr>
<td>Remained uncorrected</td>
<td>M. Allen pp.46 §7 (Discussed in section 4 of this paper)</td>
</tr>
<tr>
<td>P. 49, 1, 23, for all read small.</td>
<td>Not directly referred to in correspondence</td>
</tr>
<tr>
<td>P. 49, footnote 1, for (-\frac{w}{2q-w}) read (-\frac{w}{2(q-w)})</td>
<td>Not directly referred to in correspondence</td>
</tr>
<tr>
<td>P. 79, in the last equation, for (\frac{kf'(x)}{f(x)} \cdot \frac{dx}{dw} - k \cdot \frac{xf'(x)}{f(x)} \cdot \frac{dx}{dw})</td>
<td>Alternative working: A.L. Bowley pp. 78-82; M. Allen pp.78 §3 (Discussed in section 4 of this paper)</td>
</tr>
<tr>
<td>P. 80, in the first equation, for (k \cdot \frac{1}{e} \cdot \frac{dx}{dw} - k \cdot \frac{1}{e} \cdot \frac{dx}{dw})</td>
<td>Alternative working: A.L. Bowley pp. 78-82; M. Allen pp.78 §3 (Discussed in section 4 of this paper)</td>
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<td>P. 81, 1.4, for (\frac{1+k}{1-k} \cdot \frac{1}{E} \cdot \frac{k}{k} ) read (\frac{1-k}{1+k} \cdot \frac{1}{E} \cdot \frac{k}{k} ) and, for the expression for (E_d) in 1.18 read (\frac{1-k}{1+k} \cdot \frac{x}{E} \cdot \frac{1-q}{e} \cdot \frac{1-q}{e} + \frac{1-z}{e} \cdot \frac{1-z}{e} )</td>
<td>Alternative working: A.L. Bowley pp. 78-82; M. Allen pp.78 §3 (Discussed in section 4 of this paper)</td>
</tr>
<tr>
<td>P. 82, 1.2 of § 7, for positive read negative; and, throughout the page, for (+\frac{k}{e}) read (-\frac{k}{e}) and for (-\frac{k}{e}) read (+\frac{k}{e})</td>
<td>Alternative working: A.L. Bowley pp. 78-82; M. Allen pp.78 §3 (Discussed in section 4 of this paper)</td>
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<td>P. 83, 1.6, for negative read positive.</td>
<td>A.L. Bowley</td>
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<tr>
<td>P. 84, 1.3, the expression to the right of the second equality sign should be inverted.</td>
<td>A.L.Bowley</td>
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<td>P. 86, 1.26, for positive read negative</td>
<td>R.F.Kahn</td>
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<tr>
<td>Remained uncorrected</td>
<td>Alternative working: A.L. Bowley pp. 94-5</td>
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<td>P. 102, 1.16, for (W-K) read (\frac{W-K}{W})</td>
<td>R.F.Kahn</td>
</tr>
<tr>
<td>P. 103, 11. 2-4, for (\frac{dx}{x} ) read (\frac{1}{x} )</td>
<td>R.F.Kahn; Alternative working: A.L. Bowley P. 103</td>
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<tr>
<td>P. 182, 1.1, for (\left[1 - \frac{100}{100+p_i}\right]^x + \left[1 - \frac{100}{100+p_i}\right]^z ) read (\left[1 - \frac{100}{100+p_i}\right]^x + \left[1 - \frac{100}{100+p_i}\right]^z )</td>
<td>R.F.Kahn; D. Robertson</td>
</tr>
<tr>
<td>P. 200, line 3 from end, and p. 201, 1.1 for (r)th read (l)th.</td>
<td>R.F.Kahn</td>
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<tr>
<td>P. 219, note, 1.7 form the end, for foreign read domestic.</td>
<td>R.F.Kahn (referring to another slip)</td>
</tr>
<tr>
<td>Pp. 302-3, delete sentence beginning 1. from the end of p. 302.</td>
<td>R.F.Kahn</td>
</tr>
<tr>
<td>P. 305, 1.2, for employment read unemployment.</td>
<td>Not directly referred to in correspondence</td>
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The author wishes to thank Patricia McGuire, the Archivist at the King’s College Archive Centre in Cambridge, Rowland Thomas, Librarian at the Marshall Library Archive, and Simon Frost, Deputy Librarian at the Marshall Library, for their advice and assistance.

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Personal Correspondence:

Harrow School Archivist. 28th -30th August 2012. Email. In K.Knight (Ed).

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Letter from A.C. Pigou to Richard Stone, King’s College Archives (JNRS/3/1/102)
Letter from A.L. Bowley to A.C. Pigou, Marshall Library Archives (Pigou 2/3)
Letter from M.Allen to C.R. Fay, Marshall Library Archives (Pigou 2/3)
Note from R.F. Kahn to A.C. Pigou, Marshall Library Archives (Pigou 2/3)
Postcard from D.R.Robertson to R.F. Kahn, Marshall Library Archives (Pigou 2/3)

Published work:


Walras, L. 1874. *Éléments d'économie politique pure, ou théorie de la richesse sociale (Elements of Pure Economics, or the theory of social wealth)*.


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