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Does self-employment increase stress? A co-twin control analysis of Finnish and US twins

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ABSTRACT

Entrepreneurs enjoy autonomy and work on projects they are passionate about, which may improve their mental well-being and reduce stress. At the same time, they face several potential stressors, including long working hours. Empirical evidence on whether those who engage in self-employment experience greater stress than those who do not is mixed, which could reflect the failure to consider self-selection into entrepreneurial careers. In this paper, we re-examine the relationship between self-employment and stress, over and above the self-selection bias of individuals' predispositions, using two separate studies of monozygotic twins. In the first study (monozygotic twins from Finland), stress is reported as a perceptual measure. In the second study (monozygotic twins from the United States), we measure cortisol as a physiological indicator of stress. In both studies, we show a positive association between self-employment and stress (both perceived and physiological) above and beyond the impact of genetic and rearing factors. We also show that long working hours mediate the relationship between self-employment and stress.

Executive summary

Entrepreneurs enjoy autonomy and work on projects they are passionate about, which may improve their mental well-being and reduce stress. At the same time, they face several potential stressors, including long working hours. The question is: Does entrepreneurship ultimately decrease or increase stress? This question is important for anyone contemplating self-employment.

Empirical evidence on whether the self-employed experience greater stress than those in traditional employment is mixed, which could be caused by the failure to consider self-selection into entrepreneurial careers. Selection bias may occur because some people may be predisposed to self-employment and to stress, and that masks the effects of self-employment on stress. For example, given the known risks and long hours associated with self-employment, perhaps only people who know they cope well with stress choose to be self-employed. In this case, self-employment could cause more stress than regular employment but because self-employed people are generally better at dealing with stress, the data do not clearly show this relationship. Alternatively, perhaps certain people gravitate toward self-employment because they cannot handle the stress of regular employment, so they believe working on their own would be

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better for them. In addition, hyperactive people might gravitate toward the high-energy career of self-employment and, simultaneously, feel more stressed by nature regardless of the career context. Therefore, the relationship between self-employment and stress could appear high because self-employed people are less able to cope with work stress or are naturally more stressed, not because self-employment is inherently more stressful.

In this paper, we re-examine the relationship between self-employment and stress, over and above the self-selection bias of individuals' predispositions, based on two studies of monozygotic twins. In the first study (monozygotic twins from Finland), stress is reported as a perceptual measure. In the second study (monozygotic twins from the US), we measure cortisol as a physiological indicator of stress. We utilize a methodological tool from the health sciences called co-twin control analysis to parcel out selection bias from predispositions related to genetics and rearing. Co-twin control analysis uses monozygotic (identical) twins who share 100 % of their genetic makeup and were raised together. These models compare the stress of a self-employed twin to the stress of their employed co-twin to attribute potential differences in stress to self-employment rather than to shared genetics and rearing experiences (including shared family experiences, cohort effects, and neighborhood effects).

Across both studies, we find a positive link between self-employment and stress (perceived and physiological) that goes beyond the link associated with genetic and rearing factors. We also find that long working hours mediate the relationship between self-employment and stress.

1. Introduction

Stress has long been an important area of inquiry given its influence on people's health and well-being (Mazzola et al., 2011). *Stress* refers to the combination of environmental events that act upon individuals (i.e., stressors) and their responses to those stressors (i.e., strain) (Gonzalez-Mulé et al., 2021; Griffin and Clarke, 2011). Stressors can negatively affect physical and mental health (Thoits, 2010). Research on stress at work has been published for more than 100 years and "has enjoyed a punctuated surge of academic and practitioner interest in the last two decades" (Gonzalez-Mulé et al., 2021). Scholars have recently extended their interest in employees' stress to include the self-employed. This extension is essential given the recent popularity of self-employment as a desirable career path (e.g., gig workers; Wang and Wanberg, 2017). This career path can be extreme in both the factors that increase stress (e.g., long working hours; Bird and Jelinek, 1989) and those that alleviate it (e.g., work variety; Benz and Frey, 2008; Elfenbein et al., 2010). An investigation of how self-employment relates to stress is both timely and relevant, and the relationship is likely nuanced. As self-employment is an important, socially desirable career choice, people considering this career path must understand whether it involves increased stress.

The matter is also empirically and theoretically significant, as scholars have noted the lack of clarity regarding the relationship between self-employment and stress (Baron et al., 2016; Hessels et al., 2017; Shepherd and Patzelt, 2015). Hessels et al. (2017) identified and reviewed 15 studies that compared stress among the self-employed with that of wage workers. Lerman et al. (2021) conducted a meta-analysis of 38 studies categorizing stressors as either challenges or hindrances. Other studies have also contributed to this line of inquiry (e.g., Dahl et al., 2010; Lee et al., 2023; Lerman et al., 2020; Patel et al., 2021) and the results are generally mixed. Some studies find that the self-employed experience greater stress (Blanchflower, 2004; Jamal, 1997; Lewin-Epstein and Yuchtman-Yaar, 1991; Dahl et al., 2010). Some find that the self-employed experience less stress (Baron et al., 2016; Rahim, 1996) or experience better outcomes from stressors (Lerman et al., 2021), while others find no significant difference between the self-employed and traditional employees (Andersson, 2008; Parasuraman and Simmers, 2001; Parslow et al., 2004; Prottas and Thompson, 2006). In their review, Hessels et al. (2017) note that many early studies were based on cross-sectional designs, small samples, and descriptive statistics, with only a few employing multivariate regressions.

Two primary limitations in the extant literature may account for the variation in the results on the relationship between self-employment and stress. First, selection effects may have influenced previous studies. These effects occur when the relationship between two variables is due to something other than the variables themselves (Li et al., 2016a). In our context, selection bias may occur because some individuals may be predisposed to self-employment, and this predisposition may be related more to stress than the attributes of self-employment (Baron et al., 2016; Patel et al., 2021; Stephan, 2018). For example, perhaps only individuals who are confident in their ability to cope with stress choose to be self-employed (Zhang et al., 2019), as self-employment is associated with known risks and long hours (Bird and Jelinek, 1989; Nieß and Biemann, 2014). In this case, self-employment could cause more stress than regular employment but the data may not clearly demonstrate this relationship (Stephan, 2018) because self-employed individuals are generally better at managing stress (Lerman et al., 2020, 2021). Moreover, certain individuals may gravitate toward self-employment because they struggle to cope with stress in traditional employment, leading them to believe that working independently is a more suitable option. In addition, individuals with hyperactivity may be drawn to high-energy careers, such as self-employment and, simultaneously, may tend to feel more stressed regardless of the career context. Therefore, the relationship between self-employment and stress may be artificially inflated, as self-employed individuals might be less able to cope with work stress or more naturally prone to it (instead of self-employment being inherently more stressful).

Second, studies have employed different theoretical lenses, which have not been empirically distinguished in previous work. Potential theoretical mechanisms point to paths from self-employment to high stress via "job demands" or to low stress via "job resources" (Crawford et al., 2010; Demerouti et al., 2001). The extant literature primarily relies on cross-sectional samples, which fail to test mediators that may link self-employment to varying levels of stress (cf. Hessels et al., 2017).

To address these potential limitations of the extant literature, we investigate the relationship between self-employment and stress in two novel ways. First, we employ a methodological tool from the health sciences known as co-twin control analysis (Burt et al., 2010; Carlin et al., 2005; McGue et al., 2010; Patel et al., 2019) to separate selection bias from predispositions related to genetics and rearing. Co-twin control analysis uses monozygotic (identical) twins who share 100 % of their genetic makeup and were raised together. We use these models to compare the stress of a self-employed twin to that of their employed co-twin. The models attribute potential differences in stress to self-employment rather than to shared genetics and rearing experiences, including shared family experiences, cohort effects, and neighborhood effects. We also run univariate and multivariate genetic models using both identical and non-identical twins. These analyses show that common genetic factors influence stress and participation in self-employment, and that neglecting their links could result in inaccurate estimates of the relationship between self-employment and stress. We also have two waves of data for each twin (in Study 1), which allows us to examine whether transitioning from employment to self-employment or vice versa is associated with changes in an individual's stress. While some extant research analyzes how income changes when individuals switch between self-employment and regular employment (Sorenson et al., 2021), we have not found any studies that specifically explore how stress levels may vary following these transitions. Although our examination of changes in two-wave data does not, on its own, permit causal inferences and has other known econometric challenges (Wooldridge, 2010, pp. 321–326), it does provide supportive evidence on the relationship between self-employment and stress in conjunction with our other theoretical and empirical work.

Second, we draw on the job demands-resources model of work stress (Crawford et al., 2010; Demerouti et al., 2001) and the entrepreneurship literature (Bird and Jelinek, 1989; Lazear, 2004) to compare the countervailing influences of two potential mechanisms linking self-employment and stress—long working hours and work variety. While our framework is not exhaustive (i.e., alternative mechanisms for which we do not have empirical data may explain the relationship), we believe that testing working hours and work variety is a good starting point for understanding the link between self-employment and stress. Our findings suggest that, after accounting for selection effects, self-employment has a positive impact on stress, particularly through long working hours.

In addition to these novel analytical methods, we innovate by using a person's daily cortisol change as a physiological measure of stress in Study 2, supplementing the self-reported measure in Study 1. Cortisol is a stress-sensitive hormone (Adam et al., 2017) typically measured from saliva samples. People generally wake up with high cortisol levels that then drop during the day, but workers in stressful jobs show less of a decline than workers in less stressful jobs. In other words, they have a 'flatter diurnal cortisol slope' (Gunnar and Vazquez, 2001; Herriot et al., 2020; Stawski et al., 2013). If self-employment is more stressful than other forms of employment, we should observe a flatter daily cortisol change. Moreover, a flat cortisol slope is associated with stress that cannot be controlled (Miller et al., 2007). It may be part of a biological pathway leading to poorer health outcomes (Dmitrieva et al., 2013). In this regard, our study may provide new evidence on the presence, character, and consequences of stress in self-employment.

Finally, as Arvey et al. (2016, p. 177) note, "examining to what extent a relationship of two or three work variables is shaped by genetic and environmental factors has important theoretical significance." According to Whetten's (1989) seminal paper, the key ingredients of a theoretical contribution include the "what," "how," and "why," with the "why" being "the most fruitful, but also the most difficult avenue of theory development" (Whetten, 1989, p.493). Our study addresses the "why" by following Arvey et al. (2016) in disentangling selection and environmental causation in the relationship between self-employment and stress. Selection implies that causality flows from genetic factors to self-employment and stress. In contrast, environmental causation suggests that the relationship is primarily shaped by environmental influences—an interpretation that allows for intervention and carries policy implications. Our finding that less than half of the covariance between self-employment and stress is attributable to genetic effects indicates that the majority is environmentally driven, highlighting the need for policy interventions to better support self-employed individuals.

2. Self-employment and stress

2.1. Self-selection

Before theoretically exploring the relationship between self-employment and stress, we must acknowledge and account for the possibility that stress-prone individuals select into or out of self-employment. In simple terms, people who are naturally prone to stress may have a lower probability of becoming self-employed, which complicates efforts to isolate the independent effect of self-employment on stress. People also differ in how they handle stress, including their emotional and physiological reactions, as well as how long it takes them to recuperate from a stress-inducing event (Thiel and Dretsch, 2011). Therefore, individuals with a predisposition for enduring and coping with stress may be more likely to enter self-employment (Patel et al., 2019).

Specifically, people differ in their genetic makeup, and these genetic differences can influence their stress reactions before entering the workforce. First, genetic modifications in neurotransmitter alterations, such as those in serotonin transporter genes, mediate how individuals respond to stress, such that people with one or two copies of the short allele of the serotonin transporter promoter polymorphism exhibit increased neural activity in response to stressful stimuli when compared to individuals who have two long alleles (Hariri et al., 2002). In an extension of these results, Heinz et al. (2007) find that individuals who carry the shorter allele show greater brain reactivity to uncertain and stressful settings. Individuals with longer alleles may be more likely to enter self-employment—a self-selection effect—and therefore downplay the positive impact of self-employment on stress.

Second, genetic and environmental factors can influence personality, making an individual more susceptible to stress. For example, Taylor and Cooper (1989) discuss the Type A personality, which is characterized by high competitiveness. Type A individuals are typically very committed to their work, strive for achievement, and often feel under pressure. This makes them more prone to becoming stressed. Taylor and Cooper (1989) also discuss "hardy" individuals, who they describe as having "a positive belief in control, commitment, and challenge" and who "make positive, optimistic cognitive appraisals" (p. 21). Given these characteristics, hardy individuals are likely better able to cope with stress. Individuals who are better able to cope with stress may be more likely to enter self-employment—a self-selection effect—and, thus, hide or downgrade the positive relationship between self-employment and stress.

Ultimately, individuals may exhibit various responses to stress (Lerman et al., 2020; Lerman et al., 2021). Medical research has shown that stressful events can trigger a physiological stress response (Koolhaas et al., 2011; Neupert et al., 2007). A stress response is a change in human physiology following an environmental shift—a stressor—that significantly impacts the individual physically or emotionally (Koolhaas et al., 2011; Tsigos and Chrousos, 2002). When individuals encounter a work stressor, their body responds with several chemical changes that stimulate and control their subsequent reactions (Almeida et al., 2011; Sapolsky et al., 2000). An entrepreneur's physiological stress response is likely to be activated multiple times each day. For instance, entrepreneurs often work long hours (Blanchflower, 2004; Lewin-Epstein and Yuchtman-Yaar, 1991) and they are constantly exposed to stressors linked to their operations (Greco and Roger, 2003; Menon and Akhilesh, 1994; Watson and Everett, 1996). Outside work hours, stressors that occur during work hours can trigger a continued stress response (Kirschbaum and Hellhammer, 1994). For example, an entrepreneur's regret over choices made at work appears to cause stress outside working hours (Iyengar and Lepper, 2000). Those with less severe reactions to stress may be more likely to enter self-employment—a self-selection effect that may obscure the relationship between self-employment and stress. Relatedly, Patel et al. (2021) find that the polygenic risk score of subjective well-being is positively correlated with self-employment. Subjective well-being relates to a person's psychological resilience and their sensitivity to emotional exhaustion, which in turn influences a person's sensitivity to work stress (Arshi et al., 2021; Sardeshmukh et al., 2021).

Importantly, if an entrepreneur's stress response is activated too frequently (e.g., by chronic exposure to a stressor), the response can become blunted or dysfunctional (Heim et al., 2000; Kopp and Réthelyi, 2004) and may exacerbate the entrepreneur's stress experience (Kopp and Réthelyi, 2004). For example, helplessness occurs when individuals are subject to a chronic stressor they cannot avoid, leading to damage to their brain neurons and other physiological changes (Kopp and Réthelyi, 2004). As a result, some entrepreneurs may develop a permanent feeling of helplessness, even if the stressor becomes avoidable. Along these lines, Dahl et al. (2010) find that entering entrepreneurship is significantly and positively associated with receiving prescriptions for sedatives and hypnotic drugs, which they suggest may indicate increased stress, while Wolfe and Patel (2020) show that self-employment is associated with increased sleep, which they note could be linked to reduced stress.

The physiological stress response and the phenomenon of chronic stress are reflected in the cortisol circulating in an individual's body over a day. Cortisol is a chemical released by the body when someone encounters a stressor (Almeida et al., 2011; Tsigos and Chrousos, 2002). It enters the individual's circulation to help initiate other physiological changes aimed at handling the stressor, and to control and terminate the stress response (Almeida et al., 2011; Tsigos and Chrousos, 2002). These physiological changes increase mental focus, cardiac output, respiration, and blood flow (Tsigos and Chrousos, 2002). In addition to acute responses to stressors, the cortisol circulating in a person's body generally follows a broad pattern over a day. The level of circulating cortisol tends to rise over the first 30 min after waking (Copinschi and Challet, 2016; Miller et al., 2007). Over the remainder of the day, circulating cortisol levels tend to decrease until they reach their nadir at bedtime, resulting in a negative daily slope (Copinschi and Challet, 2016; Miller et al., 2007).

Chronic stress can change the shape of this daily cortisol pattern. Chronic stress results from recurrent difficulties or threats (Almeida et al., 2011; Miller et al., 2007), typically over months or years (Heim et al., 2000). It can damage the body's ability to regulate its cortisol levels (Almeida et al., 2011; Gunnar and Vazquez, 2001; Miller et al., 2007) so that cortisol levels do not change as much over a day and, thus, remain high at the end of the day. For individuals with chronic stress, the daily cortisol slope appears flatter when visualized as a graph (Gunnar and Vazquez, 2001; Miller et al., 2007). Overall, daily cortisol patterns can identify people with chronic stress (Dmitrieva et al., 2013; Friedman et al., 2012). Based on the above reasoning, we offer the following baseline hypothesis:

Hypothesis 1. Selection impacts the relationship between self-employment and stress (self-reported and physiological).

2.2. *Long working hours, work variety, and stress in self-employment*

Over and above the selection effects described earlier, we draw on the job demands-resources model (Bakker and Demerouti, 2017; Crawford et al., 2010; Demerouti et al., 2001) and research on self-employment (Carter, 2011; Haynie and Shepherd, 2011) to theorize two competing mechanisms that link self-employment to stress (for similar arguments on how leadership affects stress, see Li et al., 2018). First, we theorize that self-employment increases stress through long working hours (Hypotheses 2a and 2b). Subsequently, we theorize that self-employment decreases stress through work variety (Hypotheses 3a and 3b).

Job demands refer to "those physical, social, or organizational aspects of the job that require sustained physical or mental effort" (Demerouti et al., 2001, p. 501). Job demands increase stress levels (Cavanaugh et al., 2000), which can be physiologically and psychologically costly to workers (Bakker and Demerouti, 2007; Bennett et al., 2018; Sonnentag and Fritz, 2015). In this study, we use long working hours to represent job demands. Long working hours are a critical consideration when choosing self-employment (Douglas and Shepherd, 2002) and they are associated with job demands (Parker and DeCotiis, 1983; Van Der Doef and Maes, 1999). Long working hours indicate that workers have too much to do and too little time to do it (Schaubroeck et al., 1989), and they can lead to energy depletion and increased stress (Bakker and Demerouti, 2007; Demerouti et al., 2001). Given their strong commitment to their businesses (Felfe et al., 2008) and their high job demands, the self-employed typically work longer hours than their employed counterparts (Hyytinen and Ruuskanen, 2007; Kolvereid, 1996) to ensure their firms' survival (Patel and Thatcher, 2014). Long working hours can lead to stress. Thus:

Hypothesis 2a. Accounting for selection effects, the self-employed experience greater stress (self-reported and physiological) than individuals who are not self-employed.

Hypothesis 2b. Accounting for selection effects, long working hours mediate the relationship between self-employment and stress (self-reported and physiological). Specifically, there is a positive relationship between self-employment and long working hours, and a positive relationship between long working hours and stress.

Job resources also likely mediate the relationship between self-employment and stress. Job resources are rewards gained from engaging in and completing work tasks (Demerouti et al., 2001; Solomon et al., 2022), and they arise from fulfilling workers' basic needs for autonomy, competence, and relatedness (Deci et al., 2017; Ryan and Deci, 2006).[2] Therefore, they provide motivation and energy (Bakker and Demerouti, 2007), which reduce stress. This study focuses on work variety, which refers to "the degree to which a job requires employees to perform a wide range of tasks on the job" (Morgeson and Humphrey, 2006, p. 1323), as a job resource. Work variety is central to the notion of job resources (Bakker and Demerouti, 2007, 2017; Demerouti et al., 2001) because it promotes feelings of accomplishment, meaningfulness, and engagement (Christian et al., 2011; Hackman and Oldham, 1980), which can reduce stress (Bakker et al., 2014). Work variety is likely an essential mechanism in the relationship between self-employment and stress. The self-employed are often referred to as 'Jack[s] or Jill[s] of all trades' (Åstebro and Thompson, 2011; Lazear, 2004; Silva, 2007; Wagner, 2003). While work variety can also be present in traditional employment, self-employed individuals typically have a wider variety of tasks due to the nature of their role. In his seminal paper on the "Jack of all trades theory," Lazear (2004, p. 208) states:

Consider the founder of a new small restaurant. In addition to being a good cook, the founder must be able to obtain funds, hire workers, choose location and decor, obtain food supplies at a reasonable cost, keep books, and market the restaurant. Being a good cook is insufficient for success.

In research on job design, leading thinkers have viewed work variety as a positive aspect of work (Hackman and Oldham, 1976; Hackman and Oldham, 1980; Xie and Johns, 1995). Although the motivating potential of work variety differs among individuals with different needs and abilities, work variety is commonly regarded as a motivator (Ilgen and Hollenbeck, 1991; Xie and Johns, 1995).[3]

In summary, unlike employees, who often perform a constrained set of tasks, the self-employed are frequently Jacks or Jills of all trades, performing many different tasks (Lazear, 2004). They thus experience greater work variety (Åstebro and Thompson, 2011), which can lead to less stress. Based on the above reasoning, we offer the following:

Hypothesis 3a. Accounting for selection effects, the self-employed experience lower stress (self-reported and physiological) than individuals who are not self-employed.

Hypothesis 3b. Accounting for selection effects, work variety mediates the negative relationship between self-employment and stress (self-reported and physiological). Specifically, there is a positive relationship between self-employment and work variety, and a negative relationship between work variety and stress.

3. Study 1

3.1. Sample

The data[4] for Study 1 came from the Finnish Twin Cohort at the University of Helsinki and included two waves collected from the same individuals with a six-year interval between waves. The surveys captured self-employment, stress, and all of our control variables in both waves.

The response rates for the two waves of data collection were 77 % and 89 %, respectively, resulting in a total of 20,081 individuals, of which 6411 were monozygotic (MZ) twins (i.e., individuals with identical genetic composition). Given our interest in explaining the relationship between self-employment and stress beyond the potential selection effects of genetics and rearing experiences, our sample only included MZ twins who were raised together. After selecting MZ twin pairs for which information was available for both individuals, our sample contained 4164 individuals in 2082 twin pairs. This sample included twins who were concordant or discordant with self-employment. Concordant twins shared self-employment status (both were self-employed or both were not), and discordant twins did not share self-employment status (one was self-employed and one was not). In the 4164 observations of twin pairs (from 2082 pairs followed over two periods), there were 57 instances of pairs who were both self-employed, 3867 instances of pairs who were both not self-employed, and 240 instances of discordance.[5]

3.2. Measures

3.2.1. Stress

The survey captured an individual's *stress* based on their response to the Subjective Stress Scale or Reeder Stress Inventory (Reeder

[2] We conceptualize "job resources" in line with extant theory (i.e., rewards of the job) rather than the traditional definition of (just) "resources" in entrepreneurship (i.e., means to complete tasks).

[3] We note that job variety could be a double-edged sword that also represents a cost for the worker (i.e., as a source of stress) if the individual struggles to multitask or transition smoothly among different aspects of the job (see, e.g., Hafeez et al., 2024; Van Veldhoven et al., 2020). We thank an anonymous reviewer and the editor for highlighting this important point.

[4] Readers can access the data and code for both studies at: https://osf.io/u8b6h/?view_only=5500eacec2384a66b4929be13f4f406d.

[5] Specifically, in period 1, a pair of twins were both self-employed 25 times, both not self-employed 1959 times, and discordant 98 times. In period 2, a pair of twins were both self-employed 32 times, both not self-employed 1908 times, and discordant 142 times.

et al., 1973; Metcalfe et al., 2003). This is a four-item instrument based on a four-point scale (1 = very true, 2 = true, 3 = not very true, and 4 = not at all true): (1) "In general, I am unusually tense and nervous," (2) "There is a great deal of stress connected with my daily activities," (3) "At the end of the day, I am mentally and physically completely exhausted," and (4) "My daily activities are extremely trying and stressful." To ensure consistency with other stress studies, we reverse-code the measure, which ranges from 4 (lowest stress) to 16 (highest stress).

Consistent with previous studies (Korkeila et al., 1998; Reeder et al., 1973), we find that the scale has acceptable reliability, as indicated by McDonald's omega (0.80) and Cronbach's alpha (0.80). An exploratory factor analysis reveals a single factor with a non-trivial eigenvalue (consistent with Velicer, 1976). We examine measurement invariance across the two waves (Li et al., 2019; Vandenberg and Lance, 2000). Row 1 in Table 1 reports the model fit with the factor loadings constrained to be the same across the two waves. The adequate fit provides evidence of configural invariance across the waves. Row 2 in Table 1 reports the model fit with the factor loadings varying across the two waves. The model fit is no better than in Row 1 and a χ^2 test does not reject equality. Thus, there is evidence of metric invariance.

3.2.2. Self-employment

Self-employment is a dummy variable that takes a value of 1 for those individuals who reported being self-employed and 0 otherwise.

3.2.3. Control variables

(1) *Education* may be associated with greater stress (Chen et al., 2003) and we represent it using two dummy variables. The first dummy takes a value of 1 if an individual had at least some high school education but no university education and 0 otherwise, as measured in wave 1. The second dummy takes a value of 1 if an individual had a university education and 0 otherwise, as measured in wave 1. The base is individuals with a primary (elementary) school education or less. The treatment of education as an ordinal variable has a negligible effect on the results. (2) *Age* may be associated with greater stress (Scott et al., 2013). We calculate an individual's age from their birth date to the data-collection date. (3) Males may perceive less stress (Barbosa-Leiker et al., 2013). *Male* is a variable that takes a value of 1 if the individual identified as male and 0 otherwise, as measured in wave 1. (4) Marriage can be associated with lower stress (Beam et al., 2017). *Partner* is a binary variable that takes a value of 1 if an individual was married, remarried, or cohabiting, and 0 otherwise, as measured in wave 1. (5) The *time dummy* takes a value of 1 for the second wave of data collection and 0 for the first wave. We also considered estimations without control variables and obtained results similar to those reported here with control variables.

3.3. Empirical approach

Genetics and rearing experiences complicate the estimation of the relationship between self-employment and stress (Baron et al., 2016; Stephan, 2018). If we estimate our models without controlling for these selection effects, we cannot determine whether the observed effect of self-employment on stress is due to a genuine relationship or because people who naturally experience more (or less) stress tend to select self-employment.

We present two specifications to avoid this selection problem. The first is a twin fixed-effects regression. This method controls for the effects of genetics and rearing experiences on each twin pair's stress, as these factors are the same for both members. If one twin has higher (or lower) stress levels when they are self-employed than their co-twin who is not self-employed, we can infer that self-employment is associated with stress. The model pools observations from both data waves, with a time dummy controlling for the period (wave) and errors clustered by individual to account for the possible non-independence of an individual's observations across the two waves (Angrist and Pischke, 2009, pp. 312–313).

The second specification is an individual fixed-effects regression. This method examines how changes in an individual's employment status (i.e., self-employed or not) across the two periods influences their stress, controlling for all individual-level factors that are unchanged across the two periods. If the same individual experiences higher (or lower) stress when self-employed compared to when not self-employed, we can infer that self-employment is associated with stress, accounting for all fixed individual-level factors across the two periods, such as genetics and rearing experiences. For the individual fixed-effects specification, we cluster errors by twins to accommodate possible non-independence of the twins' observations. Clustered errors do not change the estimated coefficients but provide more conservative standard errors. Running our specifications without clustered errors does not change the results.[6]

3.4. Results

Table 2 details the descriptive statistics and the intercorrelation matrix. Overall, 45 % of the sample identified as male, while the mean age of the sample was 34. Table 3 shows a person's average self-reported stress changes depending on whether their self-employment status changes between the two waves. In this broad test of the relationship, if they become self-employed, they

[6] We also ran a mixed effects model with observations nested in individuals nested in twin pairs and obtained similar results (self-employment coefficient = 0.89, *p*-value = 0.00). Furthermore, we applied an additional estimation method (correlated random effects; Ashenfelter and Rouse, 1998) and obtained similar results (self-employment coefficient = 0.73, *p*-value = 0.01). This method introduces a variable equal to the average of self-employment of a twin and their co-twin (i.e., 0, 0.5, or 1) that controls for the effects of genetics and rearing experiences shared between the twins. We elaborate on this method in Study 2.

Table 1
Confirmatory factor analysis of the stress scale across the two waves (Study 1).

Factor-loading constraints	χ^2	df	CFI	TLI	RMSEA	SRMR	AIC
Factor loadings are the same in the two waves	484.36	8	0.96	0.93	0.12	0.03	69,213.6
Factor loadings vary between the two waves	481.2	4	0.96	0.87	0.17	0.03	69,218.4

Note: $N = 8328$. CFI is the comparative fit index, TLI is the Tucker-Lewis index, RMSEA is the root mean square error of approximation, SRMR is the standardized root mean square residual, and AIC is the Akaike information criterion. The *p*-value of an χ^2 test of the difference between the metric invariant and free coefficients is 0.53. Strong model fit is defined by the following criteria: standardized root mean squared residual (SRMR) ≤ 0.08 (Hu and Bentler, 1999), comparative fit index (CFI) ≥ 0.95 (Hu and Bentler, 1999), and the Tucker-Lewis index (TLI) ≥ 0.90 (Kelloway, 1998). Kenny et al. (2015) argue that the RMSEA for low df models is problematic and should not be considered. Similarly, Shi et al. (2021) "recommend researchers use caution when interpreting RMSEA for models with small df and to rely more on SRMR and CFI." The "RMSEA penalizes model complexity by incorporating df in the denominator of its formula" (Shi et al., 2021).

experience a significant increase in self-reported stress ($p = 0.02$; $N = 100$). If they leave self-employment, they do not experience a significant change in self-reported stress ($p = 0.23$; $N = 42$). When we pool the data together ($N = 142$), we find that individuals who change their employment status (from self-employed to non-self-employed, or vice versa) experience significantly higher self-reported stress when they are self-employed than when they are not ($p = 0.01$).

Some people may have changed their employment status just before the wave 2 measurement, which may have increased stress in wave 2 independent of the stress levels associated with their ongoing participation in their new employment. We can reasonably assume that the transition stress for people leaving self-employment will be at least as high as the transition stress for people entering self-employment (see, e.g., Ucbasaran et al., 2013), and that removing this transition stress will lead to a reduction in the average stress change for people leaving self-employment that is at least as large as the reduction for people entering self-employment. Therefore, the gap in the average stress change between people leaving and people entering self-employment will be at least as large as in Table 3. In addition, multiple transitions into and out of self-employment may have happened between the waves. Such transitions may be an additional source of variation in stress levels in wave 2 and may contribute to the standard errors in the results. Overall, we conclude that individuals who become self-employed experience greater increases in stress from their ongoing work than those who leave self-employment.

On average, people who remained self-employed ($p = 0.23$; $N = 106$) or not self-employed ($p = 0.00$; $N = 3916$) experience a decline in stress across the two waves. An underlying cause of stress reduction (e.g., broader economic factors) may equally affect all survey respondents. In our statistical model, we control for any such general decline between the two waves using a time dummy.

Table 4 reports the estimated coefficients for the relationship between self-employment and self-reported stress. Column 1 reports the results of the twin fixed-effects regression. Self-employment is positively associated with self-reported stress ($p = 0.00$).[7] In Column 2, we report the estimates of the individual fixed-effects regression. Again, self-employment is positively associated with self-reported stress ($p = 0.04$). A self-employed individual's self-reported stress is, on average, 24 % higher than that of their identical twin who is not engaged in self-employment.

Fig. 1 illustrates the importance of accounting for selection effects. The left-hand bar shows the estimated effect of self-employment on stress without accounting for selection effects (using an ordinary least squares estimator), and the right-hand bar shows the corresponding effect accounting for selection effects (using the twin fixed-effects estimator in Table 4, Column 1). The two estimates reveal a statistically significant and meaningful difference (i.e., a 30 % decrease).[8] We conclude that the effect of self-employment on stress is positive but artificially high when not accounting for selection effects. While the effect weakens when we control for genetics and rearing experiences, the relationship between self-employment and stress remains positive. These results provide support for Hypothesis 1.

3.5. *Mediation results*

In this section, we examine the mediating effect of the relationship between self-employment and self-reported stress. *Long working hours* is a single-item measure on a four-point scale that captures the average number of overtime hours a respondent had each day in the past year (Virtanen et al., 2012). The coding is 1 = "none or less than an hour," 2 = "one hour," 3 = "2–3 hours," and 4 = "4 hours or more." While overtime is more abstract in self-employment given that "normal" working hours are generally unspecified, it is important to capture what an individual believes is their level of "extra" work.

Work variety is a single-item measure using a four-point scale capturing the extent to which a respondent perceives their work as varying (Fransson et al., 2012). For the item "Is your present work, or the work which you last did, in your opinion," the coding is as follows: 1 = "very monotonous," 2 = "quite monotonous," 3 = "quite varying," and 4 = "very varying." Although we are limited by the availability of single-item measures in the data, research has shown that single-item measures compare well with multi-item measures and "can be used effectively to assess many relevant constructs" (Fisher et al., 2016, p. 19). Such measures are "appropriate under

[7] We also ran the analysis after excluding concordant twins and obtained substantially the same results.

[8] A Hausman test rejected the equality of coefficients from the two specifications ($p = 0.00$), which indicates the presence of the selection effects we control for in this study.

Table 2
Means, standard deviations, and correlations (Study 1).

Variable	Mean	SD	Min.	Max.	1	2	3	4	5	6	7	8	9	10	11	12
1. Stress	7.06	2.53	4	16												
2. Self-employment	0.04	0.20	0	1	0.17											
3. Secondary education	0.35	0.48	0	1	0.02	−0.16										
4. University education	0.05	0.22	0	1	0.06	−0.05	−1.00									
5. Partner	0.53	0.50	0	1	0.04	0.28	−0.35	0.21								
6. Male	0.45	0.50	0	1	0.06	0.21	−0.19	0.06	0.06							
7. Age	33.69	11.79	18	81	−0.04	0.16	−0.33	0.15	0.47	0.04						
8. Long working hours	1.59	0.91	1	4	0.20	0.49	−0.07	0.15	0.11	0.43	0.07					
9. Work variety	3.08	0.71	1	4	−0.02	0.30	0.12	0.27	0.06	0.18	0.09	0.30				
10. Stress (wave 1)	7.11	2.55	4	16	1.00	0.17	−0.03	0.03	0.06	0.03	0.01	0.11	−0.04			
11. Stress (wave 2)	7.00	2.52	4	16	1.00	0.17	0.07	0.10	0.01	0.08	−0.09	0.20	−0.02	0.47		
12. Self-emp. (wave 1)	0.04	0.19	0	1	0.17	1.00	−0.20	−0.09	0.35	0.20	0.20	0.36	0.20	0.17	0.12	
13. Self-emp. (wave 2)	0.05	0.22	0	1	0.18	1.00	−0.13	−0.02	0.23	0.22	0.10	0.49	0.30	0.13	0.17	0.90

Note: N = 8328. Correlations are Pearson, polychoric, or polyserial depending on the correlated variable type. SD stands for standard deviation.

Table 3
Average change in self-reported stress depending on changes in self-employment between the two waves (Study 1).

Wave 1	Wave 2	
	Not self-employed	Self-employed
Not self-employed	−0.12 (0.04)	0.67 (0.29)
	0.004	0.021
	3916	100
Self-employed	−0.57 (0.48)	−0.33 (0.27)
	0.244	0.231
	42	106

Note: $N = 4164$. Standard errors are in parentheses. *p*-values are shown below the coefficients. Frequencies are shown in italics below the *p*-values. The stress levels in wave 1 and wave 2 were 7.34 and 8.01 (+9.1 %) for people *not self-employed* then *self-employed*; 7.74 and 7.17 (−7.4 %) for people *self-employed* then *not self-employed*; 8.35 and 8.02 (−4.0 %) for people *self-employed* then *self-employed*; and 7.07 and 6.95 (−1.7 %) for people who were *not self-employed* then *not self-employed*.

Table 4
Self-reported stress as a function of self-employment (Study 1).

Independent variable	(1)	(2)
Self-employment	0.74 (0.19)	0.69 (0.34)
	0.000	0.044
High-school education	0.00 (0.16)	
	0.983	
University education	−0.11 (0.23)	
	0.641	
Partner	−0.09 (0.09)	
	0.331	
Male	–	
Age	–	
Group variable	Twin	Person
Cluster variable	Person	Twin
Time dummy	Yes	Yes
R^2	0.53	0.74
F p-value	0.00	0.03
N	8328	8328

Note: Estimation is by fixed effects. The dependent variable is self-reported stress. Standard errors are in parentheses. p-values are shown below the coefficients. Primary education is the omitted base group for education.

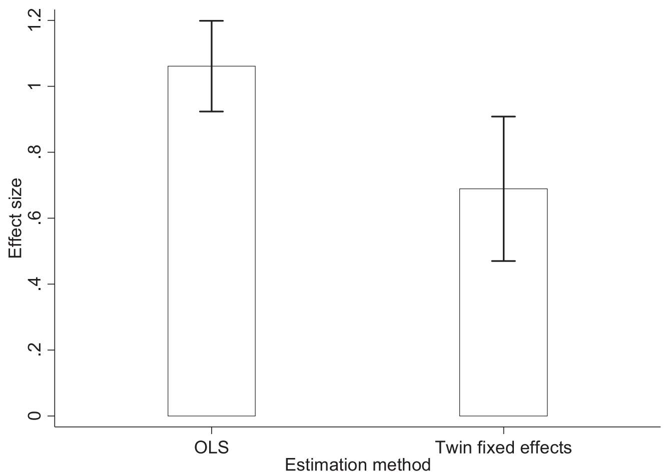

Fig. 1. Estimated Effect of Self-Employment on Self-reported Stress (Study 1)
Note: The bars show the estimated effect, and the lines show the effect plus and minus one standard error.

certain conditions and their general banishment is not justified" (Fuchs and Diamantopoulos, 2009, p. 206; see also Wanous et al., 1997; Wanous and Hudy, 2001). In particular, the conditions highlighted by Fuchs and Diamantopoulos (2009) and Allen et al. (2022)—the presence of relatively concrete constructs and the requirement of unambiguous statements of the constructs during questioning—are relevant here.

We employ a half-longitudinal mediation design (Cole and Maxwell, 2003; Kline, 2015) to investigate whether self-employment affects self-reported stress through changes in working hours and work variety. Specifically, we assess the effects of self-employment in wave 1 on long working hours and work variety in wave 2 as well as the effects of long working hours and work variety in wave 2 on self-reported stress in wave 2. The lag between the two waves means that the influence of self-employment on the two mediators may be reduced. Therefore, we also generated estimates from a restricted sample in which people did not change their self-employment status between the two waves. In this sample, self-employment acts on stress with a reduced lag. These restricted-sample estimates were similar to those reported in the study.

The use of contemporaneous measurements for the mediators and self-reported stress has the limitation that the mediators' influence on stress could be delayed (Kline, 2015), which would hinder our ability to establish causality fully. Subject to this limitation, we follow Hayes (2009, 2017) in using 1000 bootstrap samples to examine the distribution of the products of the coefficients (Booth-LeDoux et al., 2020; Rees et al., 2020). The indirect effect of self-employment on self-reported stress mediated through long working hours is 0.20 (95 % CI = [0.03, 0.46]), while the indirect effect mediated through work variety is −0.01 (95 % CI = [−0.10, 0.02]). Thus, we find evidence that long working hours mediate the relationship between self-employment and stress, but there is no significant evidence that work variety does. The indirect effect through both mediators is 0.19 (95 % CI = [0.02, 0.46]). Fig. 2 shows the path analysis for the mediation. These results support Hypothesis 2b over competing Hypothesis 3b.

3.6. *Genetic and environmental impacts on self-employment and stress*[9]

In this section, we tease apart genetic and environmental influences in the relationship between stress and self-employment. The presence of certain genetic characteristics or rearing experiences may increase the tendency to experience high stress (Federenko et al., 2006) or to participate in self-employment (Nicolaou et al., 2008). We examine whether participation in self-employment and stress are affected by the same genetic or environmental factors, which enables us to examine the extent to which such a relationship is shaped by selection or environmental causation.

We use ACE analysis to investigate potential effects. ACE analysis examines the relation of our model variables (stress, participation in self-employment, long working hours, and work variety) to unobserved genetic factors (the A in ACE), common environmental factors (the C), and unique environmental factors (the E). The genetic factors are entirely shared by monozygotic twins (with a correlation of 1) and partially shared by dizygotic (non-identical) twins (with a correlation of 0.5). The common environmental factors are entirely shared by both types of twins (with a correlation of 1), while the unique environmental factors differ by individual. These correlations allow us to estimate the relationship between the factors and our model variables (Li et al., 2016b; Nicolaou et al., 2008). The estimates can then be used to calculate the proportions of the relations between the model variables that arise from genetic and environmental causes.

We start by estimating the ACE model shown in Fig. 3. This is a univariate model—each time it is applied, the output is only one of our model variables (stress, participation in self-employment, long working hours, and work variety). The figure illustrates the normalized genetic, common environmental, and unique environmental factors influencing a single characteristic of twin 1 and twin 2 as well as the correlations between these factors. We add dizygotic twin data from the Finnish Twin Cohort to the monozygotic (identical) twin data to estimate the model. There are 3085 pairs of dizygotic twins (6170 individuals) and 1591 pairs of monozygotic twins (3182 individuals), with data for all of the main and mediator variables. The twin correlations are shown in Table 5.

Table 6 presents the results of estimating the univariate model using maximum likelihood estimation in R utilizing the OpenMx package (Neale et al., 2016) and the umx package (Bates et al., 2019). The first panel shows the results when the determined variable is stress. The model fit indices indicate that the best-fitting model has an AE form, incorporating both genetic and unique environmental factors. The model finds that 30 % of the variation in stress is attributable to genetic factors, while 70 % is attributable to environmental factors unique to each individual. A similar proportion is reported in Federenko et al. (2006), and a slightly higher proportion is found in Bogdan and Pizzagalli (2009).

The second panel shows the results with long working hours as the determined variable. The AE model is preferred. Thirty-four percent of the variation in long working hours is due to genetic factors and 66 % is due to unique environmental factors.

The third panel contains the results when work variety is the determined variable. The AE model is preferred, as 26 % of the variation in work variety is due to genetic factors and 74 % is due to unique environmental factors. These shares of genetic contributions to job characteristics are similar to those found in Li et al. (2016a).

Finally, the fourth panel presents the results when participation in self-employment is the determined variable. The AE model is again preferred. Twenty-six percent of the variation in self-employment participation is attributed to genetic factors, while 74 % is attributed to unique environmental factors. Given its superior fit, we use the AE specification in subsequent modeling.

We now proceed to a multivariate model, which partitions the covariance between stress, participation in self-employment, long working hours, and work variety into additive genetic and unique environmental factors. Fig. 4 illustrates the model.

[9] We are grateful to an anonymous reviewer who suggested using the genetic analyses in this section.

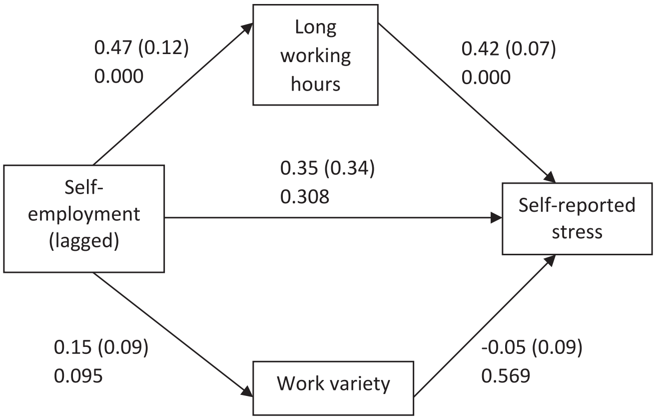

Fig. 2. Path Analysis for the Mediation (Study 1)
Note: Coefficients are unstandardized. Standard errors are in parentheses. *p*-values are shown below the coefficients.

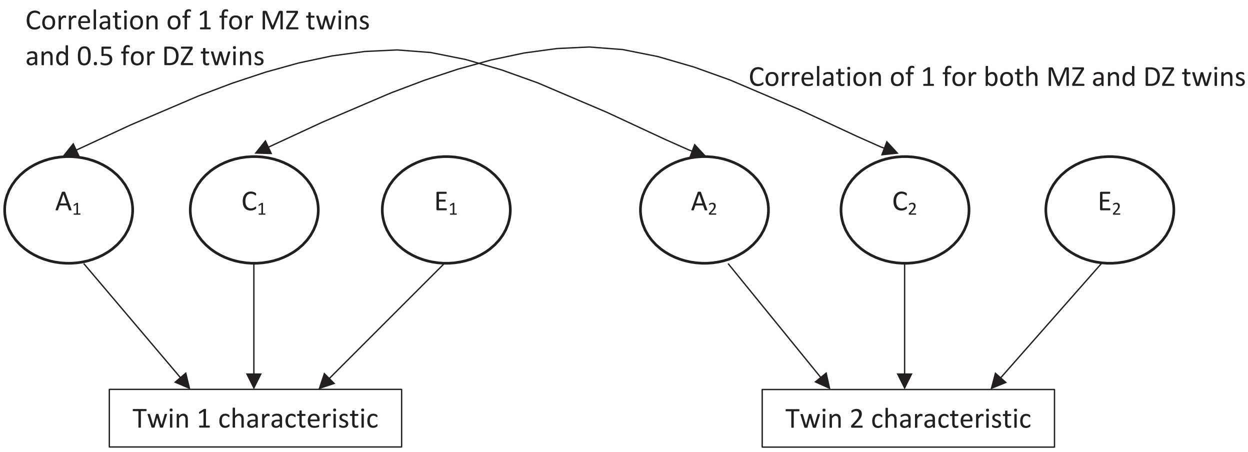

Fig. 3. Univariate model of the genetic and environmental influence (Study 1).

Table 7 details the estimated coefficients for the genetic factors. For example, the coefficient a_{11} is 1.39 ($p = 0.00$), while the coefficient a_{41} is 0.01 ($p = 0.06$). This indicates that the latent genetic factor A_1 increases stress and participation in self-employment, potentially masking any direct relationship between self-employment and stress. On their own, the coefficients do not immediately show the covariances induced between the different variables, as they can arise through changes in any of the latent variables. However, the equations in the Appendix can be used to show the percentages of the covariances attributable to genetic and unique environmental factors.

Table 8 applies the equations to illustrate the covariances between variables attributable to genetic effects and unique environmental effects as well as the percentage of total covariance attributable to each effect type. For example, the covariance between stress and self-employment attributable to genetic effects is 0.015, which is 34 % of the total covariance between stress and self-employment ($0.34 = 0.015/(0.015 + 0.029)$). At least one third of the covariance between each of our variables is attributable to genetic effects. Failing to control for these effects when estimating the unique environmental relationship between the variables may yield highly inaccurate estimates of the effect. This observation again supports Hypothesis 1 and the empirical justification for using twin control methods. The results also enable us to determine the direction of bias introduced by genetic selection effects. For example, the covariance between stress and self-employment is positive, indicating that failure to correct for these effects will result in a positive bias and tend to overestimate the size of the estimated relationship between them.

4. Study 2

4.1. Sample

The data for Study 2 come from a combination of two surveys: the Midlife in the United States survey (MIDUS 2) and the National Survey of Midlife Development (NSMD 2). Studies often use these surveys together to investigate how education, genetics, personality,

Table 5
Within-twin-pair correlations for monozygotic and dizygotic twins (Study 1).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Stress1		0.31	0.21	0.12	0.02	0.04	0.12	0.08	0.05	0.01	0.04	0.04	0.01	0.01
2. Stress2	0.14		0.07	0.17	0.03	0.07	0.12	0.10	0.07	0.02	0.09	0.09	−0.04	−0.04
3. Self-employed1	0.14	−0.02		0.60	−0.07	−0.02	−0.01	−0.05	0.24	0.26	0.23	0.23	0.13	0.13
4. Self-employed2	0.01	0.14	0.37		−0.12	−0.16	0.00	0.01	0.26	0.20	0.23	0.23	0.16	0.16
5. Secondary education1	0.03	−0.01	−0.15	−0.13		0.92	−1.00	−0.02	−0.30	−0.33	−0.24	−0.24	−0.30	−0.30
6. Secondary education2	0.01	0.03	−0.13	−0.10	0.69		0.01	−1.00	−0.28	−0.36	−0.24	−0.24	−0.31	−0.31
7. University education1	0.17	0.07	0.06	0.09	−1.00	0.03		0.89	0.19	0.19	0.04	0.04	0.20	0.20
8. University education2	0.09	0.09	0.18	0.07	0.04	−1.00	0.79		0.19	0.21	0.04	0.04	0.20	0.20
9. Partner1	0.02	0.04	0.20	0.22	−0.24	−0.22	0.17	0.19		0.77	0.09	0.09	0.57	0.57
10. Partner2	0.02	0.04	0.13	0.23	−0.22	−0.23	0.16	0.21	0.65		0.12	0.12	0.64	0.64
11. Male1	0.05	0.04	0.12	0.16	−0.27	−0.26	0.07	0.05	0.05	0.06		1.00	0.09	0.09
12. Male2	0.05	0.04	0.12	0.16	−0.27	−0.26	0.07	0.05	0.05	0.06	1.00		0.09	0.09
13. Age1	0.00	−0.02	0.15	0.20	−0.28	−0.30	0.21	0.24	0.55	0.59	0.05	0.05		1.00
14. Age2	0.00	−0.02	0.15	0.20	−0.28	−0.30	0.21	0.24	0.55	0.59	0.05	0.05	1.00	

Note: At the end of the variable names, 1 denotes twin 1 and 2 denotes twin 2. The upper-right triangle is for monozygotic twins, and the lower-left triangle is for dizygotic twins. $N = 9352$ individuals (3182 monozygotic, 6170 dizygotic). Correlations are Pearson, polychoric, or polyserial.

Table 6
Univariate ACE models (Study 1).

Model	Model fit indices					Model estimate (% variance explained)		
	df	CFI	TLI	AIC	RMSEA	a^2	c^2	e^2
Stress								
ACE	9348	1.01	1.00	43,559.1	0.00	30.4	0.0	69.6
CE	9349	0.85	0.96	43,592.9	0.03		19.9	80.1
AE	9349	1.01	1.00	43,557.1	0.00	30.4		69.6
E	9350	0.01	0.75	43,780.5	0.08			100.0
Long working hours								
ACE	9348	0.99	1.00	24,938.0	0.01	34.2	0.0	65.8
CE	9349	0.81	0.95	24,987.3	0.04		21.9	78.1
AE	9349	1.00	1.00	24,936.0	0.00	34.2		65.8
E	9350	0.00	0.75	25,214.6	0.09			100.0
Work variety								
ACE	9348	1.00	1.00	19,901.2	0.00	26.3	0.2	73.6
CE	9349	0.89	0.97	19,919.5	0.02		17.7	82.3
AE	9349	1.01	1.00	19,899.2	0.00	26.5		73.5
E	9350	0.00	0.75	20,066.9	0.07			100.0
Self-employment								
ACE	9348	0.94	0.98	−1896.4	0.02	26.3	0.0	73.7
CE	9349	0.83	0.95	−1877.7	0.03		18.3	81.7
AE	9349	0.95	0.99	−1898.4	0.02	26.3		73.7
E	9350	−0.06	0.74	−1720.2	0.07			100.0

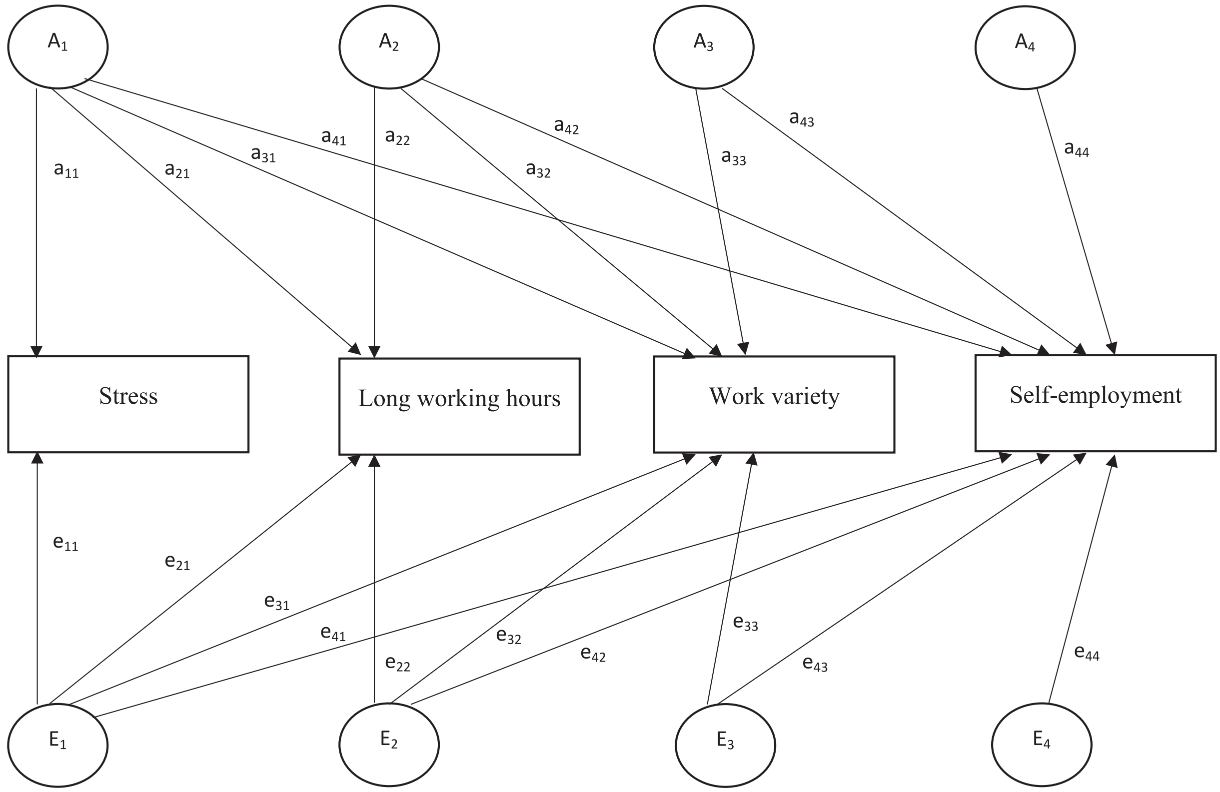

Fig. 4. Multivariate model of the genetic and environmental influence (Study 1). For ease of representation, we show only one twin. The A_i and E_j are all normal with unit variance.

Table 7

Path coefficients of the additive genetic factors (a_{MN}) and unique environmental factors (e_{MN}) (Study 1).

		N			
	a_{MN}	1	2	3	4
M	1	1.39			
		0.00			
	2	0.11	0.53		
		0.00	0.00		
	3	−0.04	0.17	0.32	
		0.02	0.00	0.00	
	4	0.01	0.05	0.00	0.10
		0.06	0.00	0.62	0.00

		N			
	e_{MN}	1	2	3	4
M	1	2.10			
		0.00			
	2	0.10	0.75		
		0.00	0.00		
	3	0.00	0.05	0.60	
		0.95	0.00	0.00	
	4	0.01	0.03	0.01	0.19
		0.00	0.00	0.00	0.00

Note: CFI = 0.99; TLI = 0.99; AIC = 85,345.8; RMSEA = 0.01. p-values are shown below the coefficients.

Table 8

Covariance attributable to genetic and unique environmental effects (Study 1).

	Due to genetic effects	Due to environmental effects
Stress with		
Long working hours	0.155	0.201
	0.44	0.56
Work variety	−0.062	0.002
	1.03	−0.03
Self-employment	0.015	0.029
	0.34	0.66
Long working hours with		
Work variety	0.085	0.040
	0.68	0.32
Self-employment	0.025	0.023
	0.52	0.48
Work variety with		
Self-employment	0.008	0.009
	0.48	0.52

Note: The percentages of total covariance attributable to each type of effect are shown below the covariances.

and cognition influence health-related outcomes (Bogg and Slatcher, 2015; Hamdi et al., 2016; Stawski et al., 2011). The twins were identified by screening a nationally representative sample of households (Kessler et al., 2004). Of the 1484 twins in MIDUS 2, we use the 561 who were MZ for our main analysis.

The NSDE 2 sample comprises a representative subsample of participants in MIDUS 2. Participants collected their saliva four times per day (upon waking, 30 min after waking, before lunch, and before bedtime) over four consecutive days to capture their cortisol levels. This collection could occur on any day of the week. As a robustness test, we also ran our estimations excluding data collected on the weekends and the results did not differ substantively. Of the 561 MZ twins in MIDUS 2, 128 twins (i.e., 64 sets) participated in the cortisol collection, giving the potential for $4 \times 4 \times 128 = 2048$ daily cortisol samples. However, some individuals did not always collect their saliva or provide complete information on covariates, resulting in a sample size of 1596 usable points of cortisol and covariate data from 59 twin pairs. In our estimations, we pool these data across days. For example, we measured cortisol levels before bed by taking up to four cortisol samples per individual over four consecutive days. A comparison of the sample in our estimations with the MIDUS 2 national sample of American twins shows no significant differences in their rates of self-employment ($b = 0.02$, $p = 0.60$), age ($b = 0.53$, $p = 0.65$), gender ($b = -0.07$, $p = 0.15$), or BMI ($b = -0.97$, $p = 0.10$). This similarity helps to establish the generalizability of our findings (Findley et al., 2021).

4.2. Measures

4.2.1. Cortisol

Cortisol is an established physiological indicator of stress (Eatough et al., 2016). In NSDE 2, participants collected saliva four times each day (upon waking, 30 min later, before lunch, and before bed) over four consecutive days. The 16 filled tubes were then sent to the University of Wisconsin, where their cortisol content was measured in nanomoles per liter (nmol/L). Previous studies have also used this cortisol data (e.g., Dmitrieva et al., 2013; Friedman et al., 2012; Seltzer et al., 2010). We log-transform the raw cortisol data to correct for skewness, following the recommendations of Bogg and Slatcher (2015), Friedman et al. (2012), and Seltzer et al. (2010). Participants were asked to collect the samples before eating, drinking (especially caffeinated products), and cleaning their teeth to avoid contamination. Other potential influences on cortisol levels, such as smoking and medication use, were measured and used as controls.

4.2.2. Hours since waking (at time of saliva collection)

Hours since waking is calculated by subtracting the collection time from the waking time for each collection for each day (consistent with Bogg and Slatcher, 2015; Lasikiewicz et al., 2008).

4.2.3. Self-employment

Self-employment is a dummy variable assigned a value of 1 if an individual responded positively to the question about self-employment status: “Do you own a business or farm?” Otherwise, the variable takes a value of 0. If we exclude farmers (4 % of the self-employed) and part-timers (those working 30 h or less per week), the results are substantially the same as those reported.

4.2.4. Average family self-employment

We measure the joint self-employment status of an individual and their twin using *average family self-employment*, which equals the average of the *self-employment* dummies for the individual and their twin (values of 0, 0.5, or 1). We use this variable to overcome any potential selection effects (consistent with Ashenfelter and Krueger, 1994; Ashenfelter and Rouse, 1998). The motivation for its use is that in estimating the effect of self-employment on stress, genetics and rearing are omitted variables that may be correlated with both, and their omission may lead to their effects on stress being attributed to self-employment, causing estimation bias. Bias may be reduced by including an estimation variable correlated with genetics and rearing that can capture their effect. Even if there is a correlation between the estimation variable and an individual’s self-employment variable, the estimator of the self-employment coefficient may still have reduced bias (Greene, 2008, p.50). Average family self-employment is correlated with genetics and rearing, so its inclusion can reduce potential bias (Ashenfelter and Krueger, 1994).

4.2.5. Control variables

(1) As cortisol tends to change less during the day for older people than for younger people (Almeida et al., 2011), we measure *age* in years. (2) Cortisol levels tend to change less under stress for those who identify as women than for men (Almeida et al., 2011). *Gender* takes a value of 1 for those identifying as a man and 0 otherwise. (3) Cortisol regulation may be disturbed for people with a higher body mass index (Björntorp and Rosmond, 2000). We calculate the *body mass index* using the following formula: (weight in kilograms)/(height in meters).[2] (4) Cortisol tends to be higher for people who smoke (Steptoe and Ussher, 2006). *Smokes* takes a value of 1 if a respondent smoked cigarettes regularly and 0 otherwise. (5) *Medication* takes a value of 1 if a respondent used medications that may affect cortisol levels, including allergy medications, cortisone, birth control, hormonal medications, steroids, and anti-depressants, and 0 otherwise (Strahler et al., 2017). We also considered estimations without control variables and obtained results similar to those reported here.

4.3. Empirical approach

We estimate the relationship between self-employment and cortisol at different times during the day. People generally wake up with high cortisol levels, which decline as the day progresses until they go to bed. However, the cortisol levels of highly stressed individuals do not decline as much as those of less stressed individuals, a regularity that has been frequently cited in the literature to identify stressful jobs and lifestyles (Gunnar and Vazquez, 2001; Herriot et al., 2020; Stawski et al., 2013). Our empirical aim is to follow this literature to see whether the self-employed show a slower cortisol decline during the course of a day relative to the non-self-employed.

Our first empirical approach is the correlated random-effects estimator (Ashenfelter and Rouse, 1998; Chamberlain, 1982; Mundlak, 1978). This approach accommodates the correlation between the error term and the self-employment term by introducing a variable equal to the average of the self-employment variable for a person and their monozygotic twin. As mentioned when we defined the variable, its strong correlation with genetic and rearing factors enables it to control for their effects on stress estimations of individual self-employment, thereby reducing the risk of omitted-variable bias. Our second approach is the twin fixed-effects estimator, which is consistent with Ashenfelter and Krueger (1994), Ashenfelter and Rouse (1998), and our Study 1. This approach removes the parts of the variables common to the individual and their twin, including genetics and rearing experiences. Thus, the regression is free from these potential selection effects.

Table 9
Means, standard deviations, and correlations (Study 2).

Variable	Mean	SD	1	2	3	4	5	6	7
1. ln(cortisol)	1.88	1.16							
2. Self-employment	0.16	0.36	0.08						
3. Average family self-employment	0.17	0.32	0.07	0.84					
4. Age	54.5	11.4	0.09	0.03	0.05				
5. Male	0.38	0.48	0.12	0.00	0.11	0.10			
6. Body mass index	26.9	5.22	−0.02	0.15	0.10	0.05	0.02		
7. Smokes	0.07	0.25	0.07	−1.00	−0.15	0.17	0.26	0.08	
8. Medication	0.37	0.48	−0.08	0.01	0.03	−0.13	−0.63	0.05	−0.13

Note: $N = 1596$. Correlations are Pearson, polychoric, or polyserial depending on the correlated variable type. SD stands for standard deviation. The high negative tetrachoric correlation (−1) between the self-employment and smokes variables arises because no one who was self-employed in our sample also self-reported as smoking. Among the non-self-employed, seven people self-reported as smoking.

4.4. Results

Table 9 presents the descriptive statistics and the intercorrelation matrix. Overall, 38 % of the sample identified as male and the average age was 54. The variance inflation factors do not exceed 1.19, so multicollinearity is unlikely to be a problem. Columns 1, 3, 5, and 7 in Table 10 report the estimates for the correlated random-effects estimator for each collection time.[10] We find no significant relationship between self-employment and cortisol at waking, at 30 min after waking, and before lunch. However, we find a positive relationship between self-employment and cortisol before bed. Columns 2, 4, 6, and 8 in Table 10 report the estimates for the twin fixed-effects estimator for each collection time. There is little evidence of a relationship between self-employment and cortisol at waking and 30 min after waking. However, a significant positive relationship exists between self-employment and cortisol before lunch and bed. Self-employed individuals' higher cortisol before bed shows that those engaged in self-employment physiologically experience greater stress after work than those not self-employed.

In Fig. 5, we graphically compare cortisol over a day for a self-employed person (solid line) and a non-self-employed person (dashed line). We assess their cortisol using the fitted values from our correlated random-effects model in Table 10. To ensure we are only representing the effect of employment status, we put all other variables (family self-employment, age, gender, body mass index, smokes, and medication) equal to their means in the MIDUS sample (alternative values of the control variables do not affect the findings). This figure illustrates that the self-employed have a flatter daily cortisol curve and higher cortisol before bed (relative to those not self-employed).

Subsequently, we test this pattern of a flatter daily cortisol curve for the self-employed in a different way. In Table 11, we present the estimates for regressions of cortisol on self-employment, pooling all data and including the variable *hours since waking* and its interaction with *self-employment*. In the case of a positive interaction, self-employed individuals would have cortisol levels that decline more slowly over the day than those who are not self-employed. When presented in a figure, cortisol levels plotted over a day would appear flatter for the self-employed than for those who are not self-employed. Column 1 in Table 11 reports the estimates for the correlated random-effects estimator. The coefficient for the *self-employment* x *hours since waking* term is significant and positive, indicating that the self-employed have a significantly flatter daily cortisol curve. A flatter daily cortisol curve is associated with higher stress (Gunnar and Vazquez, 2001; Herriot et al., 2020; Miller et al., 2007), supporting Hypothesis 2a. Column 2 reports the estimates for the twin fixed-effects estimator. Again, the coefficient for *self-employment* x *hours since waking* term is significant and positive.

Therefore, the self-employed experience a slower decline in cortisol levels over the course of a day. One way to interpret these results is to visualize the body's ability to prepare for the day ahead by raising cortisol after waking and to prepare for sleep by reducing cortisol before bed. Both self-employed and non-self-employed individuals can prepare for the day ahead. However, the self-employed are less able to lower stress before sleep compared to the non-self-employed, which is a physiological adaptation associated with chronic exposure to stress (Gunnar and Vazquez, 2001; Herriot et al., 2020; Stawski et al., 2013). In particular, this adaptation is associated with stress that the person cannot control (Miller et al., 2007). The self-employed may acutely experience this type of stress through financial exposure to the actions of partners, competitors, buyers, suppliers, and customers. For example, using the results shown in Fig. 5, self-employed individuals' cortisol levels are 53 % higher on average than those of their non-self-employed twins before bed (2.44 nmol/l and 1.59 nmol/l, respectively). We cannot discount the possibility that the self-employed's high waking and bedtime cortisol levels are caused by much longer working hours, with immediate activity upon waking and sustained activity until sleep, although such relentlessness seems somewhat less plausible. Regardless of whether the pattern results from severe stress exposure or a physiological adaptation to prolonged stress, we have evidence that self-employment is associated with higher stress levels. Overall, the results support Hypothesis 2a over competing Hypothesis 3a.

[10] We treat the variables throughout the day as distinct measurements in Table 10 because doing so allows us to explore how different groups depart from their baseline cortisol levels at different times. This approach is often used alongside an alternative examination of the group differences in cortisol variation (Seltzer et al., 2010; Stawski et al., 2011, 2013), which we present in Table 11.

Table 10
Cortisol levels at each collection time as a function of self-employment (Study 2).

	Collection time/Method							
	Waking	Waking	30 min after waking	30 min after waking	Before lunch	Before lunch	Before bed	Before bed
	CRE	FE	CRE	FE	CRE	FE	CRE	FE
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Self-employment	0.09 (0.15)	0.04 (0.14)	−0.02 (0.14)	−0.11 (0.13)	0.23 (0.17)	0.32 (0.16)	0.43 (0.22)	0.56 (0.2)
	0.543	0.762	0.857	0.378	0.173	0.048	0.047	0.005
Average family self-employment	−0.17 (0.17)		0.23 (0.16)		0.01 (0.19)		0.00 (0.25)	
	0.318		0.137		0.938		0.984	
Age	0.00 (0.00)		0.00 (0.00)		0.01 (0.00)		0.02 (0.00)	
	0.281		0.347		0.044		0.000	
Male	0.23 (0.07)		0.12 (0.06)		0.26 (0.07)		0.13 (0.10)	
	0.001		0.055		0.001		0.182	
Body mass index	−0.02 (0.01)	−0.01 (0.01)	−0.01 (0.01)	0.01 (0.01)	−0.01 (0.01)	0.00 (0.01)	0.01 (0.01)	0.01 (0.02)
	0.001	0.67	0.006	0.278	0.075	0.829	0.242	0.694
Smokes	−0.07 (0.12)	−0.01 (0.27)	−0.01 (0.11)	−0.13 (0.23)	0.21 (0.13)	0.03 (0.29)	0.42 (0.17)	0.49 (0.36)
	0.540	0.963	0.955	0.573	0.117	0.916	0.013	0.177
Medication	−0.12 (0.07)	−0.22 (0.09)	−0.18 (0.06)	−0.20 (0.08)	−0.05 (0.07)	−0.14 (0.1)	0.16 (0.1)	0.21 (0.12)
	0.083	0.017	0.004	0.013	0.499	0.15	0.098	0.087
Weekday dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.09	0.39	0.09	0.42	0.10	0.41	0.16	0.48
F p-value	0.00	0.21	0.00	0.17	0.00	0.29	0.00	0.01
N	406	418	402	414	391	402	397	408

Note: The dependent variable is ln(cortisol). Standard errors are in parentheses. p-values are shown below the coefficients. CRE denotes the correlated random-effects estimator and FE denotes the twin fixed-effects estimator.

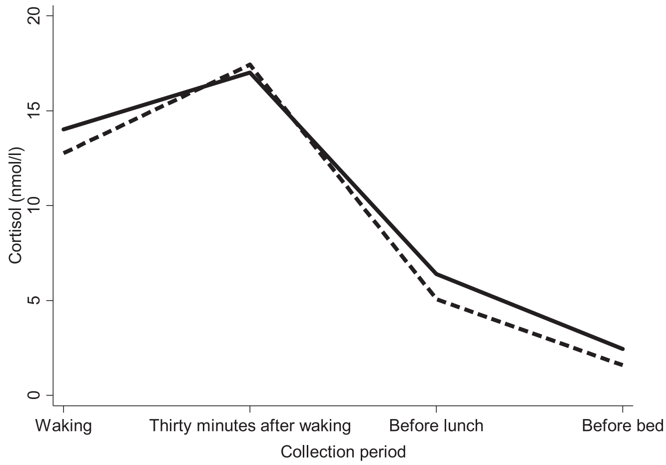

Fig. 5. Expected Cortisol Rates as a Function of Collection Period for Self-employed People (Solid Line) and People Who Are Not Self-Employed (Dashed Line) (Study 2)
Note: The figure shows expected cortisol rates derived from the coefficient estimates in Columns 1, 3, 5, and 7 of Table 10.

4.5. Separation of genetic and environmental contributions

We now apply an ACE analysis to tease apart genetic and environmental influences in the relationship between self-employment and cortisol. The approach is the same as for Study 1. We first examine the contributions of genetics and the environment to self-employment and cortisol separately, and then identify their contributions to the relationship between self-employment and cortisol. To implement the estimation, we use data from MIDUS 2 dizygotic twins and the monozygotic twins used in the previous analysis, with the determined variable being the average daily cortisol level. We have data from 59 dizygotic twins and 62 monozygotic twins. Table 12 details the within-twins correlations.

The initial univariate analysis estimates the same model as shown in Fig. 3, with variables influenced by genetic, common environmental, and unique environmental factors. The estimated coefficients are presented in Table 13. The first panel has the results when the determined variable is the average daily cortisol level. The model fit indices indicate that the best-fitting model has an AE form that

Table 11
Daily cortisol pattern as a function of self-employment (Study 2).

	Method	
	Correlated random effects	FE
Independent variable	(1)	(2)
Self-employment	0.06 (0.12)	0.09 (0.12)
	0.606	0.467
Average family self-employment	0.04 (0.12)	
	0.767	
Hours since waking	−0.27 (0.01)	−0.28 (0.01)
	0.000	0.000
Hours since waking x Hours since waking	0.007 (0.001)	0.007 (0.001)
	0.000	0.000
Self-employed x Hours since waking	0.02 (0.01)	0.02 (0.01)
	0.024	0.011
Age	0.01 (0.00)	
	0.000	
Male	0.20 (0.05)	
	0.000	
Body mass index	0.00 (0.00)	0.01 (0.01)
	0.761	0.584
Smokes	0.18 (0.08)	0.11 (0.19)
	0.031	0.554
Medication	−0.03 (0.05)	−0.06 (0.07)
	0.521	0.401
Weekday dummies	Yes	Yes
R^2	0.66	0.72
F p-value	0.00	0.00
N	1179	1213

Note: The dependent variable is ln(cortisol). Standard errors are in parentheses. *p*-values are shown below the coefficients.

Table 12
Within-twin-pair correlations for monozygotic and dizygotic twins (Study 2).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. ln(cortisol)		0.71	0.09	0.05	0.07	0.07	0.10	0.10	0.01	−0.04	−0.07	0.00	−0.10	−0.03
2. ln(cortisol)2	0.56		0.06	0.09	0.11	0.11	0.12	0.12	−0.02	−0.07	0.09	0.11	−0.07	−0.10
3. Self-employment	0.13	0.03		0.73	0.20	0.21	0.30	0.30	−0.06	0.12	−1.00	−1.00	−0.20	0.22
4. Self-employment2	−0.08	0.00	0.50		−0.04	−0.04	0.09	0.09	−0.03	0.32	−1.00	−0.96	−0.19	0.33
5. Age	0.11	0.12	0.13	0.10		1.00	0.11	0.11	0.04	0.05	0.05	−0.03	−0.17	−0.02
6. Age2	0.11	0.12	0.13	0.09	1.00		0.12	0.12	0.03	0.04	0.05	−0.03	−0.16	−0.02
7. Male	0.10	0.13	0.33	−0.08	−0.09	−0.08		1.00	0.16	−0.06	−0.09	0.37	−0.59	−0.54
8. Male2	0.07	0.11	0.12	−0.52	−0.06	−0.05	0.53		0.16	−0.06	−0.09	0.37	−0.59	−0.54
9. Body mass index	−0.11	−0.08	0.31	−0.06	−0.14	−0.15	0.14	−0.05		0.71	0.17	0.28	−0.05	0.03
10. Body mass index2	−0.04	−0.07	0.19	−0.21	−0.17	−0.16	−0.02	0.19	0.36		0.05	0.07	−0.06	0.15
11. Smokes	0.05	0.08	−1.00	−1.00	−0.18	−0.20	−0.23	−0.14	−0.29	0.12		1.00	0.30	−1.00
12. Smokes2	0.02	0.19	−0.14	−1.00	0.04	0.05	0.19	0.13	−0.02	−0.14	0.70		−0.04	−1.00
13. Medication	−0.09	−0.21	−0.39	−0.25	−0.33	−0.33	−0.01	−0.22	0.10	−0.14	0.08	0.14		0.34
14. Medication2	−0.08	−0.19	0.27	0.02	−0.14	−0.15	−0.32	−0.21	0.06	0.14	−0.19	−0.42	0.57	

Note: At the end of the variable names, 1 denotes twin 1 and 2 denotes twin 2. The upper right triangle is for monozygotic twins and the lower left triangle is for dizygotic twins. $N = 3632$ datapoints from 62 monozygotic and 59 dizygotic twins. Correlations are Pearson, polychoric, or polyserial.

Table 13
Univariate genetic models (Study 2).

Model	Model fit indices					Model estimate (% variance explained)		
	df	CFI	TLI	AIC	RMSEA	a^2	c^2	e^2
Stress								
ACE	238	0.38	0.79	318.6	0.13	63.8	0.0	36.2
CE	239	−0.09	0.69	326.7	0.16	0.0	31.2	68.8
AE	239	0.43	0.84	316.6	0.11	63.8	0.0	36.2
E	240	−0.68	0.58	337.1	0.18	0.0	0.0	100.0
Self-employment								
ACE	238	1.15	1.05	206.2	0.00	32.0	12.2	55.8
CE	239	1.14	1.04	205.4	0.00	0.0	36.6	63.4
AE	239	1.20	1.06	204.5	0.00	45.6	0.0	54.4
E	240	0.21	0.80	220.8	0.12	0.0	0.0	100.0

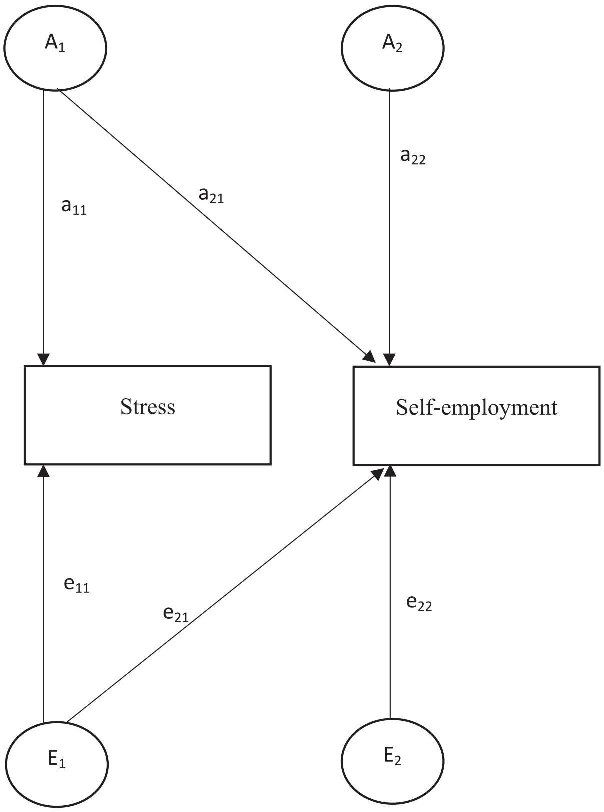

Fig. 6. Multivariate model of the genetic and environmental influence (Study 2)
Note: For ease of representation, we show only one twin. The A_i and E_j are all normal with unit variance.

incorporates both genetic and unique environmental factors. In this model, 64 % of the variation in cortisol is attributed to genetic factors and 36 % is attributed to environmental factors (in comparison, in Bartels et al., 2003, 62 % of the variation in cortisol levels is attributed to genetics). The second panel presents the results when the determined variable is self-employment. The best-fitting model is also AE (genetic-unique environmental), where 46 % of the variation in self-employment is attributed to genetic factors and 54 % to environmental factors.

Next, using the best-fitting AE model, we estimate the multivariate model in Fig. 6 to examine the genetic and environmental contributions to the association between self-employment and average cortisol levels. The estimated coefficients for the genetic and environmental factors are in Table 14. The coefficient a_{11} is 0.40 ($p = 0.00$), while the coefficient a_{21} is −0.02 ($p = 0.56$), indicating that the latent factor A_1 significantly affects stress but not self-employment.

Finally, we use the coefficients in Table 14 to show the covariances between the different variables. The equations in the Appendix illustrate the percentages of covariances attributable to genetics and unique environmental effects, which are applied in

Table 14
Path coefficients of the additive genetic factors (a_{MN}) and unique environmental factors (e_{MN}) (Study 2).

		N	
	a_{MN}	1	2
M	1	0.40	
		0.00	
	2	0.02	0.25
		0.56	0.00

		N	
	e_{MN}	1	2
M	1	0.30	
		0.00	
	2	0.04	0.28
		0.26	0.00

Note: CFI = 0.85; TLI = 0.91; AIC = 521.6; RMSEA = 0.05. p-values are shown below the coefficients.

Table 15
Covariance attributable to genetic and environmental effects (Study 2).

	Due to genetic effects	Due to environmental effects
Stress with		
Self-employment	0.010	0.012

Table 15. Genetic effects account for 45 % of self-employment's covariance with stress, while environmental effects account for 55 %. The genetic effect is, therefore, substantial in size. Still, the pathway is not statistically significant, so we cannot say its presence necessarily leads to misestimated coefficients. However, excluding genetic effects will remove this substantial source of variation, justifying our use of twin methods.

5. Discussion

Our results show a positive relationship between self-employment and stress over and above the selection effects of genetics and rearing experiences when stress is captured using self-reported and physiological measures. Interestingly, controlling for selection effects reduces the strength of this relationship, but it remains positive and significant. For Study 1, which employed a self-reported measure of stress, we demonstrate that the positive main effect is partially mediated by long working hours (a proxy for job demands), which overcomes the effects of work variety (a proxy for job resources). One possible explanation for the non-significant results for work variety is that it might be a double-edged sword representing both a job resource (variety offers excitement and fun) and a job demand (multitasking can be demanding for some people) (Hafeez et al., 2024; Van Veldhoven et al., 2020).

5.1. Contributions

We make three primary contributions to the growing literature on stress related to self-employment (Baron et al., 2016; Hessels et al., 2017; Shepherd and Patzelt, 2015; Stephan, 2018). First, we contribute to the recent literature on how entrepreneurship affects mental and physical health (Shepherd and Patzelt, 2015; Stephan and Roesler, 2010) and, in particular, to the literature on stress related to entrepreneurial careers (Hessels et al., 2017; Parasuraman and Simmers, 2001; Prottas and Thompson, 2006). We demonstrate a positive association between self-employment and both perceived and physiological stress, independent of the self-selection into self-employment of individuals prone to stress. Our finding is consistent across two datasets as well as multiple estimation methods and specifications. More specifically, our findings suggest that engagement in self-employment may disrupt the body's cortisol physiology, impairing an entrepreneur's ability to respond to stress and perform effectively at work. This form of chronic stress (Lupien et al., 2009; Miller et al., 2007) is a major cause of work burnout (Iacovides et al., 2003). Moreover, our results imply that self-employment could cause long-term, stress-related problems (Lupien et al., 2009; McEwen, 2008), supporting the claims of Jamal (1997) and Lewin-Epstein and Yuchtman-Yaar (1991) that entrepreneurship can lead to health risks.

Second, after controlling for possible selection effects, we investigate potential mediators of the relationship between self-employment and stress. Drawing on the job demands-resources model (Crawford et al., 2010; Demerouti et al., 2001) and entrepreneurship literature (e.g., Bird and Jelinek, 1989; Lazear, 2004), we test for a dual pathway of self-employment to stress (see Li et al., 2018). Our results show that, after controlling for selection effects, self-employment has a positive effect on stress through long working hours (a proxy for job demands), which overcomes a potentially negative influence on stress through job variety (a proxy for job resources, always with the caveat that job variety could be a double-edged sword. We conclude that while job resources might affect more general well-being indicators (e.g., life satisfaction, job satisfaction, happiness; e.g., Baron et al., 2016; Hessels et al., 2017), after controlling for selection effects, we did not find significant evidence that job variety specifically mediates the relationship between self-employment and stress.

Third, we contribute to the literature on the biological perspective in management (Colarelli and Arvey, 2015; Nofal et al., 2018), which focuses on the intersection of management with genetics, physiology, and neuroscience. We introduce the daily cortisol pattern, an objective measure of chronic stress, in concert with the perceived measures often used in previous work (Baron et al., 2016; Parasuraman and Simmers, 2001; Prottas and Thompson, 2006). Complementing the recent work on hormones and entrepreneurship (Nicolaou et al., 2018; Schreiber et al., 2025; Wolfe and Patel, 2017), we demonstrate that self-employment is associated with a physiological response in the daily cortisol pattern and we describe the mechanism linking them. In so doing, we offer new insights into both the within-individual changes in stress during the day and between-individual differences (entrepreneurs versus employees) in stress patterns after work (at bedtime), which provide the basis for a link to chronic stress, stress-related illnesses, and diminished well-being.

Specifically, our study relates self-employment to an inability to recover from stress, as indicated by the high cortisol levels of self-employed individuals in the evening. The self-employed appear to have more problems relaxing after work (i.e., detaching from their ventures), which could lead to stress and health-related conditions. This difficulty the self-employed face in recovering after work is a novel finding that can spark new ideas in research on stress recovery (Sonnentag et al., 2008), especially for the self-employed (Wach et al., 2021).

We further contribute by separating the genetic and environmental components of the relationship between self-employment and stress (Arvey et al., 2016). We demonstrate that genetics can influence both a person's decision to pursue self-employment and the level of stress they experience as a result, and that this selection may thereby establish a relationship between self-employment and stress. We distinguish this relation from the direct environmental causation that runs from self-employment to stress. This separation is essential for understanding the theoretical connections between self-employment and stress, and underscores the need for interventions to support the well-being of self-employed individuals.

In summary, in the spirit of a "greater plurality of research designs and methods" (Stephan, 2018, p. 314), we thoroughly examine the relationship between self-employment and stress. Our tests rely on the co-twin control methodology from the health sciences (Burt et al., 2010; Carlin et al., 2005; McGue et al., 2010), which utilizes MZ twins to control for selection effects arising from genetics and rearing experiences. While twin studies have been utilized in entrepreneurship research, the co-twin control methodology represents a novel approach that has not previously been applied in this field. It provides empirical evidence that the association between self-employment and stress is robust to selection bias (i.e., genetic and environmental influences that the twins share). After controlling for selection effects, we find that self-employment is positively associated with stress, as measured by both self-reported and physiological stress indicators. Thus, our results, which are based on robust methods, shed new light on the mixed findings regarding self-employment and stress.

In so doing, we also make a broader methodological contribution to the fields of organizational behavior and applied psychology by demonstrating the relevance of the co-twin control methodology (Burt et al., 2010; Carlin et al., 2005; McGue et al., 2010), which utilizes MZ twins to control for selection bias. In this instance, the technique helps us show that self-employment is positively associated with stress. However, the co-twin control methodology could be highly applicable to other organizational behavior topics. It allows researchers to parcel out the influence of genetics and rearing experiences, thereby isolating the effects of specific, non-shared experiences (e.g., career choices) on measurable work and life outcomes (e.g., income, promotion, satisfaction, happiness).

5.2. Theoretical and practical implications

Our findings identify long working hours as a central mechanism through which entrepreneurship generates psychological strain. This insight challenges the prevailing assumption that entrepreneurial autonomy inherently protects against work-related stress. While entrepreneurs often have discretion over their schedules, our results suggest that the pursuit of success, often coupled with resource scarcity and high personal investment, drives extended working hours that ultimately erode well-being. In this regard, we contribute to the growing literature on the 'dark side' of entrepreneurship (Shepherd, 2019) by specifying how and why autonomy can become self-endangering.

From a practical perspective, our results suggest that the glorification of excessive work hours in entrepreneurial culture may be counterproductive. The idea that founders must constantly "hustle" to succeed can obscure the very real health and performance risks associated with chronic overwork. As self-employed individuals are more likely than traditionally employed individuals to experience stress, they may take steps to help deal with it. People considering starting their own businesses should be aware of the self-employment stressors, identify their stress-tolerance levels, formulate plans to mitigate potential stressors, and develop personal stress-management techniques, such as self-help tools and/or counseling. Moreover, self-employed people may benefit from monitoring their stress by checking for abnormal cortisol responses. Indeed, sustained activation of the body's cortisol response is associated with immune-system suppression and disease exposure (Tsigos and Chrousos, 2002). We hope this study makes the self-employed more mindful of these outcomes to reduce their health risks.

In addition, policymakers, accelerators, and advisors should encourage more sustainable models of entrepreneurship by promoting awareness of work-life balance and by fostering tools that help founders monitor and manage their time. Entrepreneurship should not be framed as a limitless personal endeavor but as a professional activity that, like salaried employment, requires boundaries to prevent burnout. In practice, state bodies or organizations representing the self-employed can mitigate some of the stressors that the self-employed face by, for example, introducing one-stop shops for interactions involving administrative or taxation issues, thereby helping an economically important group with health-related vulnerabilities.

Our findings also raise questions about how long working hours and associated stress manifest in different entrepreneurial contexts. For hybrid entrepreneurs—those combining salaried employment with entrepreneurial activity—the risk of stress may be even greater, as their total workload spans multiple roles with limited recovery time. Similarly, in team-based entrepreneurship, the experience of stress may vary depending on how work is distributed, the level of trust among co-founders, and the team's ability to coordinate efforts. Future research should explore whether the negative impact of long working hours is attenuated or amplified in such contexts, and whether team composition or hybrid status moderates the relationship between workload and stress.

5.3. Limitations

As with all empirical research, this study is not without limitations. Given the nature of our datasets, we use self-employment as a proxy for entrepreneurship. We lacked the data to differentiate among various types of entrepreneurs and their businesses. Although self-employment is common in the literature, future studies may sample individuals engaged in different forms of entrepreneurship (e.g., leader of a corporate venture within an existing organization, Burgers and Van de Vrande, 2016; founder of an organization in a high-velocity environment, Roberts, 1989; or a hybrid entrepreneur, Folta et al., 2010) to corroborate or extend our results. The hypotheses in this paper were developed for self-employment in general and would need to be refined to correspond to these alternative forms. Empirically, greater specificity regarding the form of entrepreneurship and in the hypotheses may be expected to lead to more precise estimates and recommendations, both of which would be valuable outcomes.

We measured long working hours and work variety using single-item scales, whose merits and applicability have recently been subject to debate (Allen et al., 2022; Fuchs and Diamantopoulos, 2009). The use of multi-item scales in future studies could allow for an assessment of scale reliability and a fuller examination of the various facets of long working hours and work variety. However, their use could be a double-edged sword. The theoretical concepts of long working hours and work variety are based on respondents' perceptions of normal working hours and activity, and those perceptions may not be accurately captured by additional scale items that do not directly ask about long working hours or work variety, leading to reduced construct validity (Allen et al., 2022). More generally, we could use measures of job demands other than long working hours. Our model has argued that job demands cause stress and that a prominent form of job demands in self-employment is long working hours. We could identify other forms of job demands relevant to self-employment, and hypothesize and test based on those types of job demands. Similarly, we could hypothesize and test using forms of job resources other than work variety (e.g., working from the examples given in Bakker and Demerouti, 2007).

Future work could benefit from the utilization of more extended panels to capture more enduring changes in cortisol and to detect health outcomes. Scholars could then establish stronger links among self-employment, cortisol changes, and poor health outcomes. Future work could also expand the set of control variables included in the analyses to, for example, controls related to the work environment and the exploited opportunities. Their inclusion could help reduce the risk of bias from missing variables that are correlated with self-employment. This could also be part of a wider methodological extension examining potential sources of endogeneity and bias (Wooldridge, 2010, pp. 54–55). Such an extension could consider the impacts of omitted variables, potential measurement error (from constructs or the lagged variable effect in Study 2), and missing data in a unified framework.

Moreover, future work could focus on possible genetic markers associated with stress and self-employment. State-of-the-art molecular genetic research has undertaken genome-wide association studies (Luciano et al., 2018; Nofal et al., 2018). Future research can use the sum of these genome-wide genetic markers weighted by their corresponding effect sizes to derive polygenic risk scores (Choi et al., 2020) associated with stress and self-employment.

In Study 2, we measure self-employment status concurrently with cortisol. Employment status is typically stable over short periods, so the same self-employment status likely applied for at least a few months before the measurement. However, as we did not measure this status before cortisol, we cannot claim with certainty that causality runs from self-employment to stress. That said, we use twin fixed-effects estimates. For this issue to bias the results, it would need to differentially affect the co-twins in the regression.

Moreover, from a broader theoretical perspective, we cannot conclude that the increase in stress among entrepreneurs is always harmful. We do not know whether the increased stress levels always have an adverse effect on entrepreneurs or whether they could have a positive effect if they remain within an acceptable range. Future studies could attempt to empirically disentangle the nature of stress (challenge stressors versus hindrance stressors) (Lerman et al., 2020; Lerman et al., 2021) in order to provide a better understanding of the effect of the increase in stress when moving from "non self-employed" to "self-employed" and to learn about the role of stress in the entrepreneurial process.

5.4. Conclusion

Prior theoretical and empirical work on the relationship between entrepreneurship and stress has yielded inconclusive results. The effects of someone's genetics and rearing may mask any relation if they influence both participation in entrepreneurship and stress levels. This paper used Finnish and American databases of twins to separate the effects of genetics and rearing from the direct relation between self-employment and stress. Using techniques from genetic analysis, we demonstrated that genetic factors substantially influence self-employment and stress. We found that, after controlling for these influences, self-employment is associated with higher stress levels. This relation was present when stress was measured using perceived stress and the stress hormone cortisol. Our methods also enabled us to identify a significant route of influence from self-employment to stress—long working hours.

CRediT authorship contribution statement

Vangelis Souitaris: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Conceptualization. **Nicos Nicolaou:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **James Waters:** Writing – original draft, Software, Methodology, Investigation, Formal analysis, Data curation. **Dean Shepherd:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology. **Nina Hashem:** Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

- The authors have no relevant competing interests to declare.
- Given his role as Field Editor for the Journal of Business Venturing, Vangelis Souitaris had no involvement in the peer review of this article and had no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to another Field Editor.
- All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.
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Appendix A

Covariances attributable to genetics and environment in Study 1

The covariance between stress and long working hours attributable to genetics is: $a_{11}.a_{21}$
and the covariance between stress and long working hours attributable to the environment is: $e_{11}.e_{21}$.
Stress and work variety:
Genetic-attributable: $a_{11}.a_{31}$
Environmental-attributable: $e_{11}.e_{31}$
Stress and self-employment:
Genetic-attributable: $a_{11}.a_{41}$
Environmental-attributable: $e_{11}.e_{41}$
Long working hours and work variety:
Genetic-attributable: $a_{21}.a_{31} + a_{22}.a_{32}$
Environmental-attributable: $e_{21}.e_{31} + e_{22}.e_{32}$
Long working hours and self-employment:
Genetic-attributable: $a_{21}.a_{41} + a_{22}.a_{42}$
Environmental-attributable: $e_{21}.e_{41} + e_{22}.e_{42}$
Work variety and self-employment:
Genetic-attributable: $a_{31}.a_{41} + a_{32}.a_{42} + a_{33}.a_{43}$
Environmental-attributable: $e_{31}.e_{41} + e_{32}.e_{42} + e_{33}.e_{43}$

To see the origin of these expressions, consider, for example, the covariance between work variety and self-employment. Using the functional forms specified in Fig. 4, we have:

cov(work variety, self-employment)
$= \mathrm{cov}(a_{31}A_1 + a_{32}A_2 + a_{33}A_3 + e_{31}E_1 + e_{32}E_2 + e_{33}E_3,$
$A_{41}A_1 + a_{42}A_2 + a_{43}A_3 + a_{44}A_4 + e_{41}E_1 + e_{42}E_2 + e_{43}E_3 + e_{44}E_4)$
$= a_{31}a_{41}\mathrm{cov}(A_1,A_1) + a_{32}a_{42}\mathrm{cov}(A_2,A_2) + a_{33}a_{43}\mathrm{cov}(A_3,A_3)$
$+ e_{31}e_{41}\mathrm{cov}(E_1,E_1) + e_{32}e_{42}\mathrm{cov}(E_2,E_2) + e_{33}e_{43}\mathrm{cov}(E_3,E_3)$
$= a_{31}a_{41} + a_{32}a_{42} + a_{33}a_{43} + e_{31}e_{41} + e_{32}e_{42} + e_{33}e_{43},$
since $\mathrm{cov}(A_1,A_1) = \mathrm{var}(A_1) = 1$, etc.

Covariances attributable to genetics and environment in Study 2

The covariance between stress and self-employment attributable to genetics is: $a_{11}.a_{21}$, and the covariance between stress and self-employment attributable to the environment is $e_{11}.e_{21}$.

Data availability

Readers can access the data and code at: https://osf.io/u8b6h/?view_only=5500eacec2384a66b4929be13f4f406d.

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