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'THE CURSE OF THE CARIBBEAN'? AGENCY'S IMPACT ON THE EFFICIENCY OF SUGAR ESTATES IN ST.VINCENT AND THE GRENADINES, 1814-1829

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‘The curse of the Caribbean’?
Agency’s impact on the efficiency of sugar estates in St. Vincent and the Grenadines, 1814-1829

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Abstract

This study estimates agency’s impact on the efficiency of sugar plantations on St. Vincent and the Grenadines during the early 19th century. Using a panel data set covering the years 1814 - 1829, a series of stochastic frontier models are estimated to investigate whether estates employing agents were more technically efficient than those managed by the owners themselves. Multiple imputation methods are used to deal with missing data problems. There is no evidence, in any of the models estimated, to suggest that estates under agency were less efficient than those that were directed by their owners. Estimates from a number of models suggest that agent-operated estates were more efficient.

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1 Introduction

The perils of agency is a recurrent theme in the historiography of Caribbean slavery. This literature has two main branches: an older, censorious view and a more recent, revisionist perspective. Criticisms of managerial abuses first appear in contemporary publications, such as Edward Long's account of Jamaica (Long, 1774). Modern scholarship begins with Pitman (1927) and Ragatz (1931), who associated non-residency and agency with agrarian conservatism and economic neglect. Williams' famous monograph, *Capitalism and Slavery*, likewise depicts absentee landlordism as 'the curse of the Caribbean', resulting in estate mismanagement and other abuses (Williams, 1944). These contentions are repeated in numerous later studies, including Watts (1987).

Revisionist critics object that the causes and consequences of absenteeism were varied, that the ranks of non-resident owners included progressive agriculturalists, and that estates managed by agents continued to be profitable (Hall, 1964; Ward, 1988; Burnard, 2004). Apologists for agency also point out that sugar cultivation's scale, complexity and capital intensity provided incentives to develop managerial and accountancy systems, regardless of whether an owner continued to reside in the West Indies or opted to become an absentee (Sheridan, 1971; Green, 1973; Ward, 1988; Cowton and O'Shaughnessy, 1991; Cooke, 2003; Fleishman, 2004). An important contribution by Higman (2005), based on two Jamaican case studies, has given revisionism a significant boost. Rejecting much contemporary criticism of estate managers as unfounded, he argues that most non-resident owners could not have matched the performance of the attorneys they employed. Higman recasts absenteeism as an agency problem capable of solution through the development of recognisably modern management hierarchies. In his view, the desire to maintain professional reputations, underpinned by efficient contract design, reconciled the interests of planters and agents. For Higman, attorneys coerced greater amounts of labour from the enslaved, generating the levels of output needed to sustain non-residency. 'It was the management practiced by attorneys', he concludes, 'that squeezed the maximum possible product from the system and the people it oppressed' (Higman, 2005, pages 279-83).

A major weakness of the existing literature is that there exists no explicit comparison of the efficiency of estates managed by agents and those directed by their owners. An important reason for this omission lies in the fact that Jamaican sources, on which the majority of research is based, lack widespread information about owner-operated plantations (Higman, 1976). Unable to measure efficiency directly, Higman instead examined the likelihood that an estate would cease production after the legal abolition of slavery in 1833. He reports that Jamaican properties under attorney-ship in 1832 were less prone to failure by 1847. As Higman points out, however, most abandoned estates owned by residents possessed small workforces and were located in marginal areas. In contrast, sugar estates under attorneys 'occupied the best sites and were on average more productive and profitable' (Higman, 2005, pages 282-3). In consequence, the evidence of survivorship does not permit any conclusions to be drawn about the relative efficiency of agent-operated estates during the period of slavery itself.

The possibility of undertaking such an analysis for St. Vincent and the Grenadines (SVG) has, hitherto, escaped notice. This paper uses a unique panel data set of estates in SVG to investigate two quantifiable aspects of agency highlighted in the existing literature. Firstly, for the years 1801 - 1829, descriptive statistics are used to examine trends in the number and proportion of estates on SVG operated by owners or managed by agents. Secondly, for the years 1814 - 1829, stochastic frontier models are used to assess whether agency inflicted a penalty on estate performance by reducing output and revenue, conditioning on levels of inputs and factors such as estate location and calendar time. The data set and the nature of the models that are estimated pose a number of econometric challenges, including those of missing data and unobserved heterogeneity. Using multiple imputation models to deal with missing data and estimating a range of stochastic frontier models for panel data, results show no evidence that estates managed by agents were less technically efficient than those operated by their owners. There is some evidence that they were more efficient. A verdict on whether agent-operated estates were more efficient than those operated by their owners is hindered by the absence of knowledge about the true population relationship that should be estimated.

Section 2 presents the background to the study, including the existing historical literature and sources. Section 3 outlines the methodology. Section 4 presents the results of the descriptive and inferential analysis and section 5 concludes.

2 Background

2.1 Study region and sources

Britain acquired SVG from France at the end of the Seven Years' War (1756-63) during the middle phase of European imperial expansion in the Caribbean (Higman, 1984). For most of the period from 1805 to 1829, the colony's plantations ranked second in the British West Indies after Jamaica, producing, on average, 7.8% of total sugar output (Watts, 1987). Previous appraisals of agency in SVG are strongly critical, reflecting the influence of the older literature (Spinelli, 1973; Marshall, 2007). These studies do not, however, subject the hypothesis of an agency penalty to rigorous testing: their evidence is selective and includes counter-examples of poor management by resident planters. Contemporary sources similarly allege that malpractice occurred on some properties. Absentee Hugh Perry Keane complained of 'the villainous mismanagement of my Estate' and visited St. Vincent twice to improve conditions on Liberty Lodge.[1] A second non-resident owner, James Adam Gordon, sent a special visiting attorney to inspect his Fairhall property in 1824. The subsequent reports criticised the performance of the estate's management (Smith, 2008). However, despite their detail, these are only two examples. The interpretive weight they can carry is limited.

This study combines data from two principal sources to investigate the agency question. Information about an estate's agency status is derived

[1] Diary of Hugh Perry Keane, Virginia Historical Society, Keane Family Papers, Mss 1 K197 a15 [1803], endnotes.

from the registry returns. Compulsory registration of slave ownership in the British West Indies was introduced between 1812 and 1819 to police enforcement of the abolition of the transatlantic slave trade and to regulate inter-colonial movements of slaves. During the study period considered in this paper, registry returns took place on SVG in 1817, 1821, 1824, 1827 and 1830 (Higman, 1984). The person making these returns was required to declare 'the right or character in which the party making such Return holds possession of and claims title to such Slave or Slaves, namely whether as Proprietor, Lessee, Mortgagee, Sequestrator, Guardian, Committee, Trustee, Receiver, Executor, Administrator, Attorney, or otherwise' (Laws of St. Vincent, 1884). Data for output and inputs is obtained from St. Vincent's Crop Returns, the primary purpose of which was to assess planters' contributions to the parish levy (Laws of St. Vincent, 1884). These sources are described in the appendix and maps of St. Vincent and the Grenadines are presented in Figures 1 and 2.

2.2 Stochastic frontier analysis

The traditional, deterministic, production function of microeconomic theory shows the maximum output that a technically efficient production unit can generate, given its inputs.[2] Stochastic frontier models make explicit allowance for the possibility that production units exhibit technical inefficiency and therefore produce 'below' their frontier. The models define, for each firm, a stochastic frontier which comprises a function of factors of production and other variables that are considered to influence output, plus a symmetric, zero mean, idiosyncratic error term, intended to capture factors such as measurement error, model misspecification and the effects of unpredictable shocks to the frontier (such as adverse weather events, luck and so forth). A second, non-negative, random variable is subtracted from the stochastic frontier to represent technical inefficiency. Estimation of cross-sectional stochastic frontier models was first proposed in the work of Aigner et al. (1977) and Meeusen

[2]Survey material for frontier models is taken from Stevenson (1980), Coelli et al. (1998), Greene (2011) and Kumbhakar et al. (2012).

Figure 1: Map of the Greater Caribbean region [Source: Authors and Bodleian Library, Oxford].

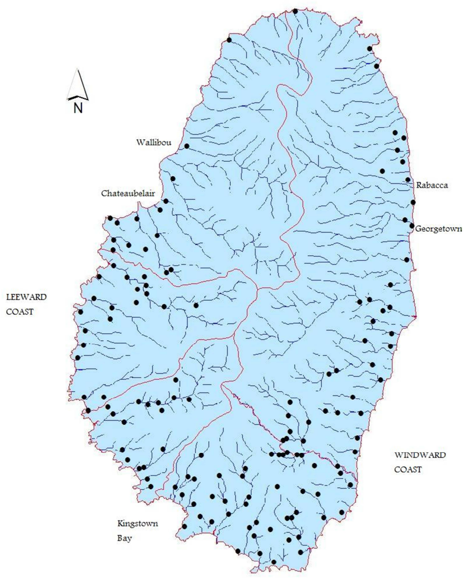

Figure 2: St. Vincent: river systems, parish boundaries, and Kirby estate mill Locations. [Parishes (clockwise from top): Charlotte's (largest), St. George's, St. Andrew's, St. Patrick's, St. David's. Circles denote all archaeological mill sites surveyed by I. E. A. Kirby. Source: St. Vincent National Trust]

and van den Broeck (1977). Pitt and Lee (1981) extended the cross-sectional framework to panel data, and there has followed a large literature extending the methodology in both cross-sections and panels (Greene, 2011).

Stochastic frontier models have found some application in the economic history literature. Grabowski and Pasurka (1989) examined the relative efficiency of slave agriculture using data from cotton plantations in the American South in 1860, and Hofler and Folland (1991) presented follow-up analysis. Field-Hendrey (1995) applied a cross-sectional stochastic frontier model to investigate whether slave farms in the antebellum American South were more efficient than free farms. She found evidence to suggest that the gang system made slave farms superior; without the gang system, there was no difference. In the wider literature Burhop and Lübbers (2009) used a panel model to investigate whether cartels and managerial incentives affected the performance of coal mining firms in Germany at the turn of the 20th century. They found that cartelisation did not affect efficiency, but that bonuses paid to board members did.

Stochastic frontier models for panel data appear well-placed to investigate the impact of agency on estate efficiency on SVG. Two complicating factors present themselves, however. The first concerns disentangling any true, agent-related, efficiency effects from time-invariant, estate-specific, effects. Put another way: how is one to know whether any effect of agency on estate efficiency is truly caused by the use of an agent or is the result of agents being found on estates which are, intrinsically, less or more efficient, owing to the omission from the model of unobservables such as soil quality and estate elevation? The second problem concerns missing data: the agency status of estates can only be measured in the years of the registry returns, information on the acreage of estates is limited, and output and input data is missing for some crop returns.

Although the historical literature has not attempted to disentangle agency and estate effects, studies of slavery in the Caribbean and United States demonstrate awareness of the problem. Higman (2005, pages 18-19; 1996, page 307) notes that absentee management was more prevalent among sugar planters because other crop combinations were less profitable. He also observes that, once estates reached a threshold size of 1,000 acres or 250 slaves, owners were liable to hand control to an agent and retire to Britain. Investigations of the relative efficiency of slave and free labour in the antebellum cotton South suggest that scale is correlated with productivity-augmenting characteristics, including location (soil type, relief, and climate) and managerial structures. Olmstead and Rhode (2008, page 1153), for example, report that plantation fixed effects are strong determinants of cotton picking productivity. In the wider literature, the difficulty of separating the impact of managerial and structural characteristics on efficiency is a feature of stochastic frontier analyses in agriculture. Structural effects can be decomposed into on-farm and off-farm factors. The former include location and size; the latter upstream and downstream relations with suppliers and purchasers, that in turn affect credit relations and debt financing (Van Passel et al. 2006, pages 3-6). In this paper, we test the sensitivity of the results our baseline frontier models to making allowance for estate-specific fixed and random effects.

Regarding the problems of missing data, there exist a large suite of routines which allow investigators to impute values for missing data in order to conduct what is known as 'valid inference' (inference in which estimators exhibit the desired properties of consistency, the correct p-values under the null hypothesis, and so on (London School of Hygiene and Tropical Medicine, 2013)). We use approaches based on multiply-imputed data sets using chained equations and the hotdeck method to estimate our models, combining the results across these multiple data sets using the rules of Rubin (1987).

3 Methodology

3.1 Stochastic frontier models

The baseline stochastic frontier model used in this paper is that of Battese and Coelli (1995), using as the inefficiency term a normal distribution whose expected value is made a function of explanatory variables (including the agency status of the estate) and which is truncated from below at zero. Index the $N = 108$ sugar estates used in the inferential analysis by i, $i = 1, \ldots, N$, and time by t, $t = t_0, \ldots, T$, where $t_0 = 1814$ and $T = 1829$. The unbalanced nature of the panel means that not all estates are observed from 1814 and not all survive until 1829. Define the sugar output of estate i at time t as $y_{it} > 0$, a function f of the factors of production, the independently and identically distributed idiosyncratic error v_{it} and an inefficiency term, independent of v, given by the random variable $\phi_{it} \in [0, 1]$:

$$y_{it} = f(\mathbf{x}_{it}, \boldsymbol{\beta}) \exp(v_{it})\phi_{it}. \tag{1}$$

$\mathbf{x}_{it}$ is a $1 \times K$ vector of observed explanatory variables, including factors of production and a time trend and $\boldsymbol{\beta}$ is a $K \times 1$ parameter vector to be estimated. Taking the logarithm of both sides of Eq. (1):

$$\ln[y_{it}] = \ln[f(\mathbf{x}_{it}, \boldsymbol{\beta})] + v_{it} + \ln[\phi_{it}].$$

Assume a Cobb-Douglas production function, that is, define $f \equiv \beta_0 x_{1it}^{\beta_1} x_{2it}^{\beta_2} x_{3it}^{\beta_3}$, where x_{1it} is the number of slaves used by estate i at time t, x_{2it} is the total acreage of the estate and x_{3it} measures the number of years from 1813. Further, define $u_{it} = -\ln[\phi_{it}]$ as the inefficiency term. The baseline model to be estimated is then:

$$\begin{aligned}
\ln[y_{it}] &= \ln(\beta_0) + \beta_1 \ln[x_{1it}] + \beta_2 \ln[x_{2it}] + \beta_3 \ln[x_{3it}] + v_{it} - \ u_{it}, && \text{(2a)}\\
v_{it} &\overset{\text{iid}}{\sim} \mathcal{N}(0, \sigma_v^2), && \text{(2b)}\\
u_{it} &\sim \mathcal{N}^+(\mu_{it}, \sigma_u^2); \quad v_{it}, u_{it} \text{ independent}, && \text{(2c)}\\
\mu_{it} &= \beta_4 + \sum_{j=5}^{9} \beta_j x_{ji} + \beta_{10} \ln[x_{3it}] + \beta_{11} x_{11it}. && \text{(2d)}
\end{aligned}$$

Eq. (2d) shows that the mean of the (untruncated) normal distribution in Eq. (2c), μ_{it}, is made a function of estate-specific characteristics: the estate's agency status x_{11}, the parish/island location of the estate, given by the dummy variables $x_5, \ldots, x_9$,[3] and x_3, the time trend variable which is

[3] The parishes on St. Vincent are: Charlotte's (omitted from the model), St. George's, St. Andrew's, St. Patrick's and St. David's. An additional dummy variable represents

also included in the stochastic frontier. The presence of x_3 in both the frontier and the inefficiency term allows separation of Hicks-neutral technological change (change which operates equally on labour and capital, leaving marginal products unchanged) from time-dependent inefficiency effects which are not captured by other variables in Eq. (2d) (Battese and Coelli, 1995, page 329; Coelli et al., 1998, page 37).

Estimation is carried out using maximum likelihood, which permits simultaneous estimation of the parameters in both the frontier and inefficiency parts of the model. The new `sfpanel` commands for Stata were used (Belotti et al., 2012). Since u_{it} is a normal random variable truncated at zero, the following are the expressions for its expected value and variance (Wang, 2002, page 244):

$$E[u_{it}] = \sigma_u \left(\Lambda + \frac{g(\Lambda)}{\Phi(\Lambda)} \right), \quad (3)$$

$$\text{var}(u_{it}) = \sigma_u^2 \left(1 - \Lambda \left[\frac{g(\Lambda)}{\Phi(\Lambda)} \right] - \left[\frac{g(\Lambda)}{\Phi(\Lambda)} \right]^2 \right), \quad (4)$$

where $\Lambda = \mu_{it}/\sigma_u$ and g and Φ are, respectively, the probability density and cumulative distribution functions of a standard normal distribution. These expressions may be used to estimate the marginal effects for the impact of agency on average estate inefficiency. We use the finite difference method for marginal effects (Cameron and Trivedi (2005, page 123)) to calculate the conditional expectations $E[u_{it}|\hat{\boldsymbol{\beta}}, \mathbf{x}^*]$ using Eq. (3), where the regressors $\mathbf{x}^*$ refer to those in Eq. (2d), chosen so that the 'representative estate' is on Charlotte's Parish, and its efficiency is evaluated over the years 1814 - 1829. We calculate separate conditional expectations for agents and owners. Finally, second order Taylor polynomials are used to obtain approximations for $E[\phi_{it}|\hat{\boldsymbol{\beta}}, \mathbf{x}^*]$ for agents and owners. These are required because ϕ_{it} is a nonlinear function of u_{it}.[4]

To test the sensitivity of the results of the baseline model to accommodating unobserved, estate-level, effects, two 'unobserved effects models' are

estates on the islands of Bequia, Mustique, Canouan and elsewhere.

[4] Since $\phi_{it} = \exp(-u_{it})$, a Taylor polynomial may be used to approximate $E[\phi_{it}|\hat{\boldsymbol{\beta}}, \mathbf{x}^*]$

also estimated, namely the 'true random effects' (TRE) and the 'true fixed effects' (TFE) models proposed by Greene (2005). These replace the common intercept term in Eq. (2a) with c_i, a random variable representing a time-invariant, estate-specific effect:

$$\ln[y_{it}] \quad = \quad c_i + \beta_1 \ln[x_{1it}] + \beta_2 \ln[x_{2it}] + \beta_3 \ln[x_{3it}] + v_{it} - \ u_{it}, \qquad (5)$$

where v_{it} and u_{it} are as defined in Eqs. (2b) to (2d) and only the time-varying variables x_3 and x_{11} are included in Eq. (2d). The distinction between the TRE and the TFE model lies in whether or not c_i is correlated with the regressors. The TRE model assumes that c_i is uncorrelated with the regressors; the TFE model assumes that c_i and the regressors are correlated. The model in Eq. (5), whether TRE or TFE, imposes 'strict exogeneity', conditional upon the unobserved effect c_i. That is, controlling for the regressors and c_i, $x_{is}, s \neq t$ is assumed to have no partial effect on y_{it} (Wooldridge, 2002). Wooldridge explains the implication of this assumption for models of farming: c_i can capture the effects of estate-specific quality of land and other unobserved, time-constant factors, which can influence yields. In any t, controlling for inputs to the production process and c_i, inputs in other periods are assumed not to affect output in t.

3.2 Missing data

A typical estate record is shown in Table 1, where problems relating to missing data (represented by a '.') are made clear. There is almost full information available for the number of slaves and the output of the estate (these data mainly come from the crop returns), but there are many missing values for acreage and agency status (these mainly come from the registry

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as follows:

$$E[\phi_{it}|\hat{\boldsymbol{\beta}}, \mathbf{x}^*] \approx \exp(-u_{it})|_{E[u_{it}|\hat{\boldsymbol{\beta}},\mathbf{x}^*]} + \frac{1}{2}\text{var}(u_{it}|\hat{\boldsymbol{\beta}}, \mathbf{x}^*) \exp(-u_{it})|_{E[u_{it}|\hat{\boldsymbol{\beta}},\mathbf{x}^*]},$$

where expressions for $E[u_{it}|\hat{\boldsymbol{\beta}}, \mathbf{x}^*]$ and $\text{var}(u_{it}|\hat{\boldsymbol{\beta}}, \mathbf{x}^*)$ are obtained from Eqs. (3) and (4), evaluated at the appropriate values of the regressors in $\mathbf{x}^*$: Charlotte's parish, for the years 1814 - 1829 and for agents and owners (separately).

Date	Sugar	Slaves	Acres	Agency
31 Jan 1817	58	54	247	1
31 Jan 1818	65	54	.	.
31 Jan 1819	91	113	247	.
31 Jan 1820	88	116	.	.
31 Jan 1821	117	93	.	.
31 Jan 1822	110	88	240	1
31 Jan 1823	84	86	.	.
31 Jan 1824	108	85	.	.
31 Jan 1825	.	85	.	1
31 Jan 1826	.	.	.	.
31 Jan 1827	94	77	240	.
31 Jan 1828	92	76	.	1
31 Jan 1829	65	74	.	.

Table 1: Typical missingness pattern in the data set (the estate is 'Belmont, second settlement', in St. David's Parish, and '.'s represent missing values).

returns). Including only those observations for which complete information is available reduces the sample size from around 1670 to around 350. This presents three major problems for estimation: firstly, inconsistency and inefficiency in parameter estimation; secondly, problems of convergence; thirdly, the 'incidental parameters problem' in fixed effects models, which can lead to inconsistent variance parameter estimates owing to the small number of observations which are used to estimate the nuisance, estate-specific, parameters (Belotti and Ilardi, 2012). Multiple imputation methods are used in an attempt to overcome these problems and obtain consistent parameter estimates.

There is a large literature on the use of imputation methods (Little and Rubin (2002) and Andridge and Little (2010)). For a covariate X_1, the 'missingness mechanism' describes the probability of a variable having missing values, given values of the variable itself and other variables in the data set. Values are 'missing completely at random' (MCAR) if the probability of being missing is unrelated to the values of X_1 itself or to the values of any other variable(s) $\mathbf{X}$: $\Pr(\text{missing on } X_1 \mid X_1,\ \mathbf{X}) = \Pr(\text{missing on } X_1)$. Observations are 'missing at random' (MAR) if the probability of observations being missing is not related to the values of the variable itself but is related to the values of another variable (or variables): $\Pr(\text{missing on } X_1 \mid X_1,\ \mathbf{X}) = \Pr(\text{missing on } X_1 \mid \mathbf{x})$. Finally, 'missing not at random' (MNAR) occurs if the missingness mechanism is not MCAR or MAR, implying that the probability of observations being missing is a function of the unseen values of X_1. Since missing values on variables are, by definition, not observable, it is difficult, often impossible, to establish the true nature of the missingness mechanism.

When observations are MCAR, a model estimated using only the observed data will yield unbiased parameter estimates, albeit with a loss of efficiency. When the missingness mechanism is MAR or MNAR, biases result. Modern statistical methods use a range of approaches to attempt to correct for missingness, offering the opportunity to explore the sensitivity of results to the choice of method. Two 'multiple imputation' approaches are used in this paper - a 'hot deck' approach (Mander and Clayton, 1999) in which, for each estate, a line of data with missing values is replaced by complete line of data sampled from the estate using the approximate Bayesian bootstrap method of Rubin and Schenker (1986); a 'multiple imputation using chained equations' approach (van Buuren et al., 1999), in which a series of chained regressions are estimated and used to impute missing values. Both approaches may be used if the missingness mechanism is either MAR or MCAR.

Prior to carrying out multiple imputation, each estate in the sample was considered in turn and ownership, returnership and acreage information between observation points was filled in where it appeared reasonable to do so (this occurred when, for example, acreage or the name of the owner was the same in successive registry returns). For both approaches, five imputed data sets were generated and the results were combined using Rubin's rules (Rubin, 1987). The multiple imputation estimator of a parameter θ_K, $K = 5$, is the simply the average of the parameter estimates across the five imputed models. The variance of the estimator is given by the sum of the within- and between-imputation variances, adjusted for bias as a result of using a finite number of imputed data sets, as follows:

$$\text{var}(\theta_K) = \text{var}_w + \frac{K+1}{K}\text{var}_b.$$

where $\text{var}_w = K^{-1}\sum_{k=1}^{K}\text{var}(\theta_k)$ is the 'within-imputation' variance and $\text{var}_b = (K-1)^{-1}\sum_{k=1}^{K}(\hat{\theta}_k - \bar{\theta}_K)^2$ is the 'between-imputation' variance. The test statistic for a null of no effect is then given by the ratio of θ_K to the square root of the variance, and has a t distribution on degrees of freedom which are a function of the number of imputations, var_w and var_b (Little and Rubin (1987, page 257); Andridge and Little (2010)).

4 Descriptive and inferential analysis

4.1 Descriptive analysis

The final data set used for descriptive analysis contains 4165 observations on 215 estates. 3573 observations come from crop returns and 592 from registry returns. Based on a comparison of the number of slaves with those recorded in the census years of 1817 and 1825, it is estimated that the data set includes approximately 83% of the slaves on SVG. The remaining 17% were based in the port city of Kingstown and in smaller settlements, working in crafts or domestic service outside the estates.

Figure 3 plots the total number of estates recorded in the crop returns and registry returns by year, broken down according to estate location (St. Vincent or the Grenadines) and crop type. The figure also delineates estates that were recorded as being agent-operated in the registry returns, together with three key events: the closure of the transatlantic slave trade in 1807, the volcanic eruption of 1812 and the trade shock of 1822, when restrictions on West Indies exports to the United States were relaxed. The definition of agency is based on the authors' classification of ownership as recorded in the registry returns: agent-operated estates are defined as those where the returner is classified as a manager (16%), attorney or agent (12%), trustee, executor, guardian or receiver/administrator (2%), tenant (0.2%), or where the returner shares his or her surname with the owner or part-owner (2.0%). If this information is not available, estates are classified as being in agency when the owner's name is not the same as the returner's name (26%) and when it is possible to identify an agent from a previous or subsequent Registry Return (13%). An estate is classified as being owner-operated if the returner is classified as the owner (27%) or if comparison within estates, over time, suggest this to be the case (0.2%). It was not possible to assign an agency status in about 2% of cases.

Owners typically possessed a single estate: of the 115 owners listed in the Registry Return of 1817, nine operated two estates and two operated three estates; for the Registry Return of 1827, the figures are eight and two, respectively, for 73 estates. Most agents similarly managed a single property: of the 121 agents listed in the Registry Return of 1817, twelve managed two estates, four managed three estates and one managed five estates; of the 107 agents in the return for 1827, five managed two estates, two managed three estates, and four managed more than four estates, including one agent who managed twelve estates. Owners and agents were also distinct groups: few owners ever acted as agents and vice versa.

Figure 3 shows that the number of estates increased from 148 in 1804 to 158 in 1808, before declining to 109 in 1830. After a small reduction after 1808, the number of estates on St. Vincent was reasonably constant, at around 100, whereas the number of estates on the Grenadines fell. In 1804, St. Vincent had approximately two-and-a-half times the number of estates than the Grenadines; by 1830, it had approximately seven times as many. Almost all of the estates on St. Vincent produced sugar. On the Grenadines, the fall in numbers was due, primarily, to the closure of cotton-producing plantations. In 1804, 31 units, producing minor staples, were operating on SVG, but by 1824 this number had fallen to 18 and by 1829 it was two. Comparison of the crop return and the Registry Return data shows good agreement. Neither the volcanic eruption of 1812, nor the trade shock of 1822, had a major impact on trends.

Figure 4 plots the number of slaves recorded in the crop and registry returns. The size of the enslaved population on the colony changed little

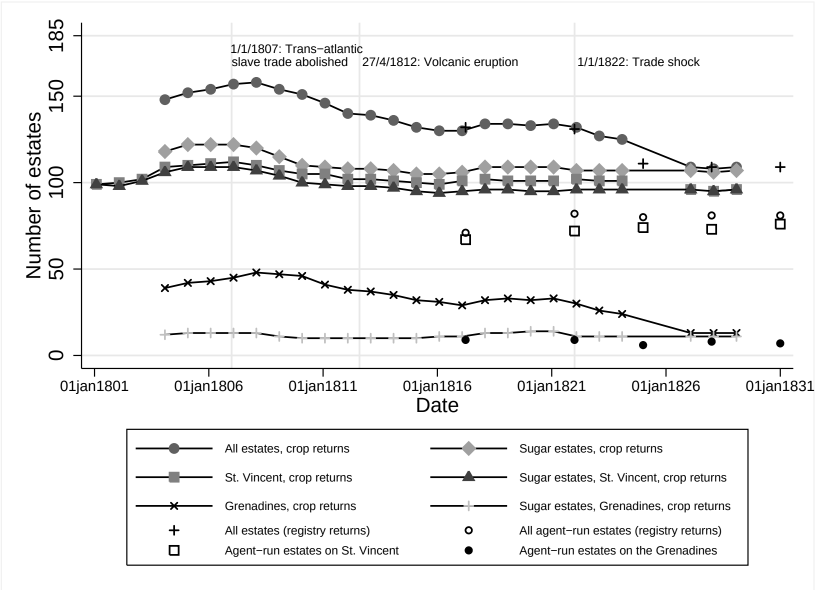


Figure 3: Number of estates and number of estates operated by agents, based on crop return and registry return data, 1801 - 1830 (data for 'all estates' and Grenadines is for 1804 - 1830 only).

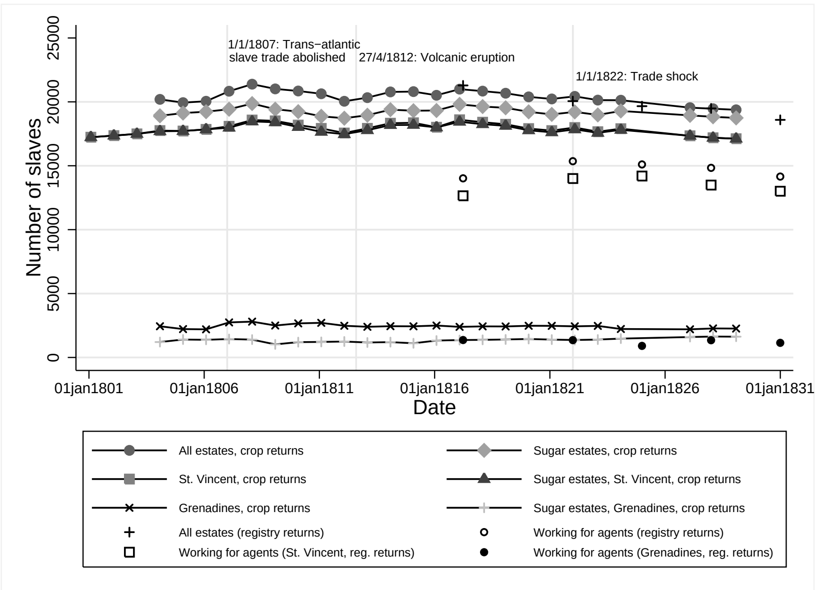


Figure 4: Number of slaves and number of slaves working for agents, based on crop return and registry return data, 1801 - 1830 (data for 'all estates' and Grenadines is for 1804 - 1830 only).

	1817		1821		1824		1827		1830	
	Owner	Agent	Owner	Agent	Owner	Agent	Owner	Agent	Owner	Agent
Number of estates by location (proportion of total number of estates at location in parentheses)										
St. Vincent	33 (0.33)	67 (0.67)	26 (0.27)	72 (0.73)	21 (0.22)	74 (0.78)	20 (0.22)	73 (0.78)	14 (0.16)	72 (0.84)
Grenadines	14 (0.70)	9 (0.30)	9 (0.50)	9 (0.50)	7 (0.54)	6 (0.46)	5 (0.38)	8 (0.62)	6 (0.46)	7 (0.54)
Average number of slaves on an estate (standard deviations in parentheses)										
St. Vincent	163 (96)	200 (132)	144 (85)	191 (120)	150 (85)	191 (124)	158 (93)	185 (113)	157 (95)	183 (108)
Grenadines	81 (84)	152 (166)	103 (78)	151 (192)	154 (64)	151 (114)	178 (36)	169 (104)	185 (34)	164 (125)
Number of estates producing the following crop combinations[a]										
Sugar and rum	8 (0.28)	21 (0.72)	7 (0.21)	26 (0.79)	3 (0.60)	2 (0.40)	2 (0.20)	8 (0.80)	-	-
Sugar, molasses and rum	23 (0.32)	48 (0.68)	20 (0.31)	44 (0.69)	19 (0.21)	72 (0.79)	21 (0.23)	71 (0.77)	-	-
Cotton only	7 (0.70)	3 (0.30)	1 (0.17)	5 (0.83)	1 (0.33)	2 (0.67)	0 (0.00)	2 (100.00)	-	-

Table 2: Estate characteristics according to agency status, 1817 - 1830.

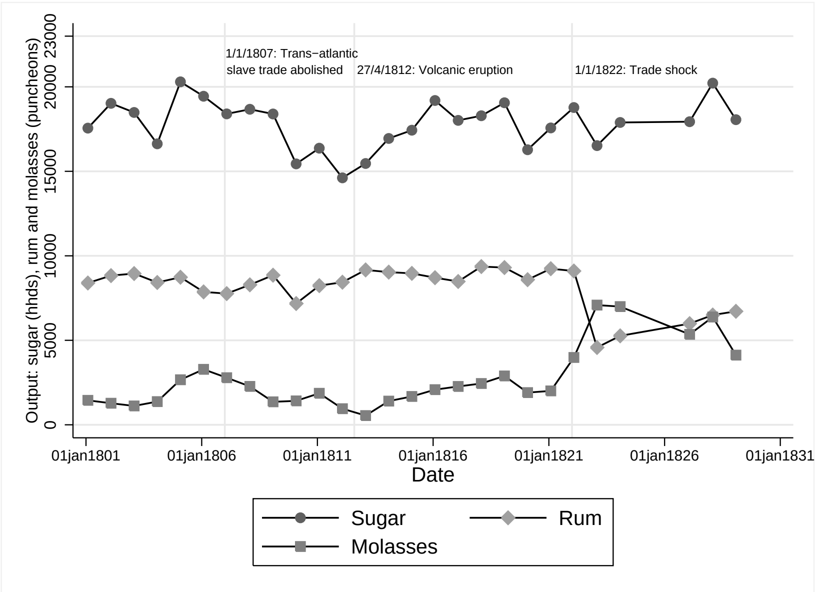
[a] Figures presented only for crop combinations with ten or more estates in one of the Registry Return years.

over time: the crop returns record total numbers as being 20195 in 1804, rising to a peak of 21385 in 1808 and falling to 19380 by 1829. The registry returns data provide good agreement. The number of slaves working for agents remained reasonably stable over time, although the proportion rose slightly, reflecting a small reduction in the colony's slave population over the study period.

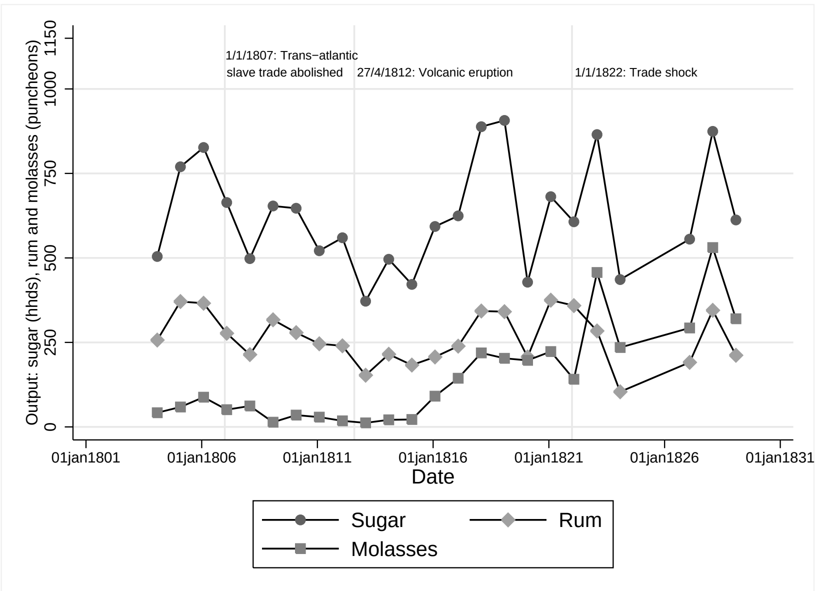
Summary statistics for estates classified according to their agency status are presented in Table 2. The proportion of agent-managed properties rose over the study period because estates which ceased production in the decade after 1817 tended to be directed by their owners. By 1830, 84% of properties on St. Vincent and 54% on the Grenadines were in the hands of agents (up from 67% and 30% in 1817, respectively). Estates run by agents were, on average, larger than those operated by their owners. The six largest units (with slave numbers ranging from 410 to 689) were all controlled by agents. Data from the registry return of 1817 reveals that, when estates are compared according to agency type, there is little difference between the gender ratio (the proportions of male and female slaves on owner- and agent-operated estates were 0.52 and 0.50, respectively), the average ages of males and females (26.0 (standard deviation = 2.7) and 27.2 (standard deviation = 2.8), respectively) and the proportion of slaves assigned to skilled occupations (0.13 and 0.10, respectively).

Figures 5(a) and (b) show the output of sugar, rum, and molasses on SVG. Sugar production declined on both locations between 1805 and 1812. Thereafter, output recovered but remained more volatile on the Grenadines (probably reflecting greater variation in annual rainfall). The share of the three major staples grown on the smaller islands remained small, at around 7% to 10%. After 1822, rum production fell sharply in both locations while molasses output surged. The temporary shift from rum to molasses in 1822 most likely reflects changing trading conditions, which favoured the export of crude molasses, rather than the distillation of rum on the island.[5]

[5]Export data for 1822, 1824, and 1827-9 show that molasses were chiefly exported to Britain (82% market share), with North America and the USA providing a secondary outlet (15%). In contrast, rum's largest market was North America and the USA (50%), with Britain occupying a supplementary position (27% share). A fall in the price of rum



(a)



(b)

Figure 5: Output of sugar, rum and molasses on (a) St. Vincent and (b) Grenadines (vertical scales differ) [Sugar is measured in hogsheads containing 1,500lbs; rum in puncheons containing 110 imperial gallons; molasses in puncheons containing 100 imperial gallons].

The minor staples of coffee and cocoa were only produced on St. Vincent and cotton only on the Grenadines. Analysis of the revenues generated by sugar, rum and molasses shows that these three outputs accounted for around 97% of the colony's total in 1804 and 98.5% in 1824. In summary, sugar and sugar-related crops dominated production on the islands.

Figure 8 in the appendix plots labour productivity data for the sugar-related crops. Output per slave of sugar and rum was about one and a half to three times higher on St. Vincent than on the Grenadines. Productivity of sugar on St. Vincent fell from 1803 and continued to fall after abolition of the trans-atlantic slave trade, recovering after 1812. Productivity of rum and molasses remained relatively stable until the 1820s, whereas for sugar it fluctuated during the early years of the survey period.

4.2 Inferential analysis

Results combining the parameter estimates from the five imputed data sets, for the baseline models and the unobserved effects models, are reported in Table 3. The full set of results for each imputed data set are reported in Tables 5 to 9 of the appendix.[6] All models use cluster-robust standard errors at estate level, to allow for the likely correlation of error terms over time within estates. All models were estimated on 108 sugar estates, with 1666 observations in total. The average number of observations per estate is 15.4.

The general findings from the two baseline Battese-Coelli models reported in Table 3 are as follows. The 'inefficiency component' $\lambda = \sigma_u/\sigma_v$ is significantly different from zero, lending support to the use of the stochastic frontier model. The combined results from the hotdeck data sets and the chained equations data sets are reasonably similar, especially for the statistically significant coefficients: there is a strong, positive relationship between the number of slaves employed on an estate and the output of sugar. The

relative to molasses, coupled with the lifting of restraints on British-U.S. trade in 1822, boosted exports of molasses to the USA (Gayer et al. (1953, pages 674-9, 719-20, 729-30); Ragatz (1927, pages 9-10); Cole (1938); Davidson (1900, pages 33-34)).

[6]The true fixed effects models based on hotdeck imputations encountered convergence issues and so cannot be reported.

All models:
$N = 1666$ observations on 108 estates
Average length = 15.4 years

	Battese Coelli (1995)		True random effects		True fixed effects
	Hotdeck	Chained	Hotdeck	Chained	Chained
Frontier					
Ln Slaves	1.011***	1.067***	0.423***	0.871***	0.759***
	(15.59)	(21.01)	(3.55)	(9.44)	(6.88)
Ln Acres	0.033	-0.010	0.152	0.021	0.019
	(0.54)	(-0.20)	(1.23)	(0.50)	(0.40)
Ln Time	-0.018	0.011	-0.027	0.034	0.032
	(-1.27)	(0.48)	(-2.18)	(1.95)	(1.86)
Constant	0.179	0.047	1.200	0.549	-
	(0.55)	(0.21)	(2.21)	(1.14)	-
Mean inefficiency					
St. George's Parish	0.238	0.337	-	-	-
	(0.996)	(1.48)	-	-	-
St. Andrew's Parish	0.255	0.152	-	-	-
	(1.05)	(0.56)	-	-	-
St. Patrick's Parish	0.996***	1.025***	-	-	-
	(4.61)	(4.28)	-	-	-
St. David's Parish	0.635**	0.638*	-	-	-
	(2.89)	(2.84)	-	-	-
Grenadines	1.324***	1.465***	-	-	-
	(5.12)	(5.14)	-	-	-
Agency	-0.238*	-0.273*	-0.624	-0.567	-0.533
	(-2.42)	(-2.69)	(-1.28)	(-1.80)	(-1.76)
Ln Time	-0.072*	-0.098	-0.658	-0.157	-0.154
	(-2.02)	(-1.73)	(-1.51)	(-1.18)	(-1.23)
Constant	0.191	-0.074	-	-	-
	(0.87)	(-0.79)	-	-	-
λ maximum	3.79***	2.97***	11.00***	2.59***	2.56***
λ minimum	3.36***	2.59***	6.52***	3.16***	3.16***

Table 3: Sugar efficiency models: combined results for each model using the five imputed data sets. Tables 5 to 9 in the appendix present the results for each imputed data set. Omitted dummy variable for location is Charlotte's Parish. t statistics in parentheses. λs in the final two rows report the maximum and minimum values of $\lambda = \sigma_u/\sigma_v$ from the imputed data sets. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

elasticity of output with respect to the number of slaves is estimated to be around 1. There is no evidence to suggest that acreage and output are related. This is possibly the result of measurement error in the acreage variable, which captures the total estate acreage rather than the acreage under crop.

In the 'inefficiency' part of the model, it should be noted that, given the specification in Eq. (2d), a positive coefficient suggests greater *inefficiency*. The parameter estimates for agency in the two baseline models are -0.238 ($p = 0.02$) in the hotdeck model and -0.273 ($p = 0.01$) in the chained equation model. Using Eqs. (3) and (4) and the Taylor approximation that is discussed in footnote 4, Figure 6 plots the estimate of the average efficiency of estates under agents and owners on Charlotte's parish over the time horizon of the study, based on the results of the third imputation from Table 5. Also provided, for comparison, are the averages for the Grenadines. The plot shows that efficiency increases gradually over time, with estates operating under agents on Charlotte's parish enjoying around a 6% premium, as measured by the ratio of the estimated average efficiency of agent-operated estates to the average efficiency of owner-operated estates. Average levels of efficiency on the Grenadines are seen to be much lower, which is consistent with the story in Figure 8. The agency 'premium' appears to be higher (at around 20%).

Strong locational effects are also found in the baseline models. The evidence in Table 3 suggests that the parishes of St. Patrick's and St. David's were, on average, less efficient than Charlotte's Parish. Charles Shephard, the contemporary historian of St. Vincent, observed that planting in St. Patrick's parish was inhibited by steep gradients and thinner soils. He regarded St. David's more favourably, noting that it was the first area to be settled by the French colonists (Shephard, 1831, pages 13-14). Mid-twentieth-century surveys, however, indicate that these two parishes were generally inferior in terms of soil quality, drainage, slope, and susceptibility to erosion (Watson et al., 1958, pages 47-70). Analysis of sugar mill locations similarly indicates that estates in St. Patrick's and St. David's parishes occupied sites with greater mean slope and height above sea level, which is consistent with

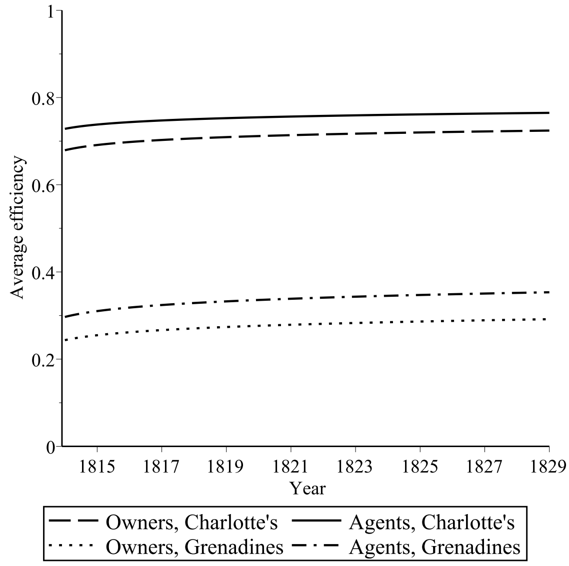


Figure 6: Estimated average efficiency of sugar production for estates on Charlotte's Parish and the Grenadines according to agency status, 1814 - 1829.

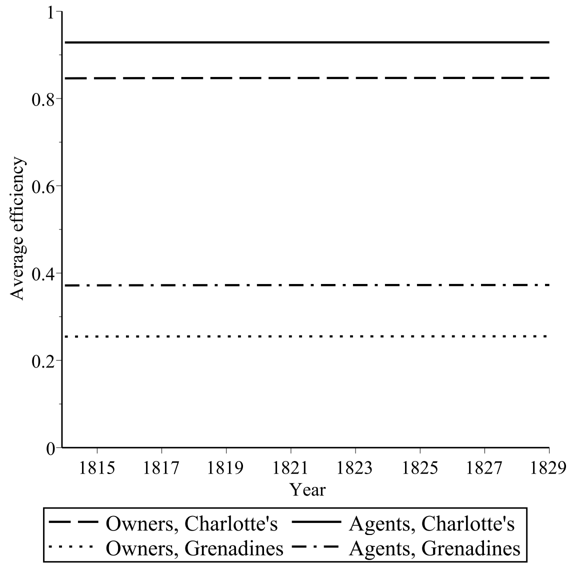


Figure 7: Estimated average efficiency of revenue generation from sugar, molasses and rum production for estates on Charlotte's Parish and the Grenadines according to agency status, 1814 - 1829.

	Price in t	Price in $t+1$
Battese Coelli (1995)		
Hotdeck	-0.353*	-0.265**
	(-2.52)	(-2.73)
Chained	-0.360***	-0.358***
	(-3.47)	(-4.52)
True random effects		
Hotdeck	-0.504	-
	(-0.83)	-
Chained	-0.463	-0.461*
	(-1.88)	(-2.43)
True fixed effects		
Chained	-0.389	-0.374*
	(-1.77)	(-2.36)

Table 4: Results of revenue efficiency models: sensitivity analysis of results for agency. SEs adjusted for clustering by estate. t statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

higher erosion risk.[7]

Turning to the sensitivity analysis of the agency result, the TRE and TFE models that are reported in Table 3 report negative parameter estimates for agency, but none of them reach statistical significance at the 5% level in a two-tailed test. Taken together, the results of Table 3 provide no evidence that agent-operated estates were less efficient than those that were operated by their owners, and some evidence that they were more efficient.

Additional sensitivity analysis was used to investigate whether the results for agency change when the output measure used for the frontier model is total estate revenue from sugar crops, measured as the sum of the value of the sugar, rum and molasses output at constant London prices for domestic and imported goods (using the Gayer-Rostow-Schwartz commodity price index, see Mitchell (1988)). This measure captures the income that planters hypothetically would have received had output of sugar, rum, and molasses been shipped to London and sold at average prices. The point estimates and t-statistics for the measures of agency for these models are reported in Table

[7]Results of GIS analysis. The meta data is described in Smith (2010, pages 4-6).

4. The first column results calculates revenue using output and prices in the same year; the second uses output in year t and price in year $t+1$. The results are, generally, consistent with those already discussed, in that there remains no evidence that agents were less efficient than owners at running the affairs of the estate, and some evidence that they were more efficient. Figure 7 plots the average efficiency using results from imputation 2 of the Battese-Coelli (1995) chained equation model for revenue, calculated using the price in t. It shows, again, evidence of an agency premium for revenue generation and a large difference between efficiency of estates on Charlotte's parish and the Grenadines. There is no evidence to suggest that efficiency in revenue generation changed over time.

5 Discussion

The findings of the stochastic frontier models provide no evidence to support the contention that agents were, on average, less efficient than owners in producing output and revenues. On the contrary, there is some evidence to suggest that they were more efficient. These results do not absolve agents entirely of the traditional charges levied against them, nor are they strong enough to endorse all aspects of Higman's revisionism. Absentee planters expressed concern, during the amelioration debates, that maximising sugar production was achieved at too great a cost in terms of the health and welfare of the enslaved population (Forster and Smith, 2011, page 909). Unfortunately, demographic sources are not sufficient to test whether the success of agents on SVG was founded on unsustainable labour management practices.

The finding that agency was widespread on SVG is consistent with the pattern of settlement. Following the conclusion of the 2nd Carib War (1795-6), the last remaining tracts of land on the Windward side were brought into cultivation. After 1814, new sugar estates on the main island could only be created through merging or sub-dividing existing properties, as cane cultivation entered its mature phase. The opportunities for industrious settlers to become planters, therefore, receded. By the early nineteenth century, the mean age of owners lay between 53 and 54 years, reflecting the tendency of planters to acquire estates through inheritance or marriage (Smith, 2013). Niches were thus created for managers to occupy, whose knowledge and energy can be expected to have been at least equal to that of their employers. Studies of the principal-agent problem elsewhere in the Atlantic economy demonstrate that stricter accounting techniques and better designed contracts (including the use of bonds and staged salary rises) were effective in minimising managerial abuses (Carlos and Nicholas, 1990). Although there is little direct evidence regarding practices on SVG, the use of these techniques on the nearby colony of Barbados suggests strongly that owners could draw on a common pool of knowledge, helping to explain the absence of an agency penalty (Smith, 2006, page 236).

Higman's bolder claim that the development of managerial hierarchies rendered absenteeism economically viable is harder to substantiate using the results. The Battese-Coelli models find agency and efficiency to be positively associated, but cannot separate a true agency effect from unobserved structural estate characteristics. Greene's models address this problem, but a statistically significant effect of agency is not observed in all of the models. Further, it is difficult to know whether, over time, managers were drawn to properties that were more productive and, therefore, capable of bearing the cost of an agent's salary.

Future research could consider exploring the potential endogeneity problem in the relationship between agency status and estate performance. As noted in section 3, the stochastic frontier models impose what is called 'strict exogeneity' on the regressors, an assumption which may not hold if, over time, the efficiency of estates affected their agency status. There appears to be limited examination of such a problem in the stochastic frontiers literature: Habib and Ljungqvist (2005) estimate stochastic frontier models of managerial performance and test for possible bias owing to endogeneity between firm performance and the incentives of managers; Bloom and Van Reenan (2007), in their study of management practices across a range of firms and countries, use instrumental variables in an attempt to circumvent similar problems. Future research could also explore more refined methods of multiple imputation and assess the sensitivity of results to the technique used to generate the imputed data sets.

Considering the findings as they stand, this study presents evidence that estates in agency were at least as productive as those operated by their owners. It is important to distinguish, however, between relative and absolute efficiency. Nothing in the preceding analysis implies that plantation agriculture was superior to alternative modes of production. Comparative analysis simply provides a rationale for the prevalence of absenteeism by suggesting that agents achieved output levels at least as good as owners could have secured with the same inputs. The comparisons are, however, centered on conditions prevailing during the early nineteenth century. Whether non-residency compromised planters' capacity to respond to social and economic challenges over a longer time period remains an open question.

Acknowledgements

We thank Federico Belotti, Silvio Daidone, G. Ilardi and V. Atella for writing the Stata programs `sfpanel` and `sfcross` that were used in the inferential analysis (Belotti et al., 2012). We thank Silvio Daidone, in particular, for his generous help with the estimation of the stochastic frontier models. For their comments on earlier versions of this paper, we thank participants in the Society for Historical Archaeology's 2013 conference on Historical and Underwater Archaeology, Leicester; the seminar series for the Centre for Historical Analysis and Related Research, York; the Association of Business Historians' 2010 conference on Global Business and Global Networks, York, and the British Group of Early American Historians' 2009 conference, Stirling. Analysis was carried out using Stata v.12 and Maple v.16. Mistakes remain our own.

A Appendix: Sources of data and additional results

The data set spans the years 1801 to 1830, with no data available for the years 1825 and 1826 and limited information for 1801 - 1803 and 1830. It is compiled from two main sources. The 'crop returns' (which cover the years 1801 - 1824 and 1827 - 1829) record annual declarations of slave numbers, estate size in acres, crop outputs and details of land ownership at the time the source was compiled. Information on the ownership status of estates is available in the crop returns of 1814, 1818 and 1824. The 'Registry Returns' are official documents monitoring the numbers of slaves on plantations in the years 1817, 1821, 1824, 1827 and 1830.[8]

The crop returns are in three formats:

1. a pocket book listing output of estates on SVG between 1801 and 1814, including ownership information in 1814, accessioned with 'An Almanack Calculated for the Island of St. Vincent';[9]

2. a printed book covering the years 1801 - 1818 and 1819 - 1824. This includes information on ownership in 1818 and 1824 and is entitled: 'An Account of the Number of Slaves Employed, and Quantity of Produce Grown, on the Several Estates in the Island of Saint Vincent and its Dependencies, from the year 1801 to 1818; and from that period to 1824, inclusive';[10]

3. a printed book detailing crop returns for 1827 - 1829, including ownership information in 1829.[11]

Crop return data is not available for the Grenadines prior to 1804.

The crop returns list estates by owner, together with crop output and information about the number of slaves, on pain of a penalty of £50 currency (Laws of St. Vincent, 1884, 200-14). A consolidating law enacted in 1821 required that these returns be submitted between the 1st and the 15th of January each year and so a date of 31st January is assumed for all crop returns. We further assume that the recorded owner refers to the owner of the estate at the time the source was compiled, unless the estate ceased production before this date, in which case it is assumed that ownership information refers to the owner of the estate at the last date for which output information for that estate is available. The data for output, slaves and acreage in the manuscript for 1801-14 (described in point 1. above) agrees with the printed book for 1801-18 (described in point 2. above), but with fewer missing data points. Hence the source described in point 1. above for estate acreage data between 1801 and 1814 is used.

The registry returns record the names of owners, returners and details of slave numbers. The Registry Return of 1817 is a full census of the enslaved population. Returns for 1821, 1824, 1827 and 1830 list between-Registry

[8] The National Archives: Public Record Office.

[9] Kingstown: St. Vincent, 1808 and 1809, Bodleian Library of Commonwealth and African Studies at Rhodes House, University of Oxford, RHO Retro Staff.

[10] Compiled from the official returns. (Kingstown: St. Vincent, 1825).

[11] From Shephard (1831, appendix, vi-xxvi).

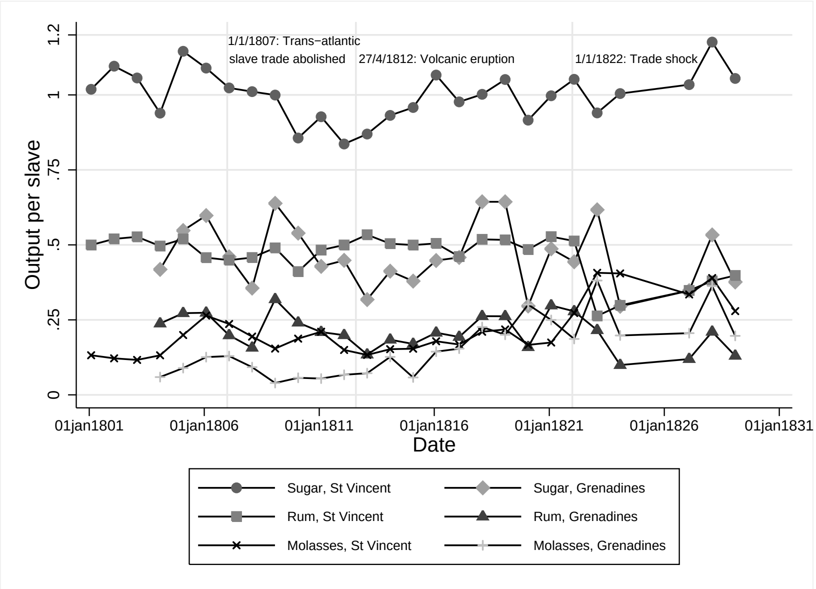


Figure 8: Output per slave for sugar and related crops [Sugar is measured in hogsheads containing 1,500lbs; rum in puncheons containing 110 imperial gallons; molasses in puncheons containing 100 imperial gallons].

Return additions (mainly births) and losses (mainly deaths) to each estate's population.

Comparison of the Registry Return data for 1827 suggests that a small number of non-sugar producing estates recorded as operating in the Registry Return were not tabulated in Shephard's crop return account. Most likely, these ceased operations prior to 1829, when Shephard compiled his information.

All models:
$N = 1666$ observations on 108 estates
Average length = 15.4 years

	Imputed data set				
	1	2	3	4	5
Frontier					
Ln Slaves	1.005***	1.047***	0.996***	1.035***	0.973***
	(20.81)	(17.36)	(18.68)	(15.03)	(21.16)
Ln Acres	0.043	0.019	0.042	0.018	0.043
	(0.71)	(0.31)	(0.73)	(0.30)	(0.75)
Ln Time	-0.022	-0.020	-0.023	-0.008	-0.015
	(-1.85)	(-1.81)	(-1.87)	(-0.62)	(-1.24)
Constant	0.133	0.076	0.215	0.127	0.328
	(0.46)	(0.25)	(0.73)	(0.40)	(1.15)
Mean inefficiency					
St. George's	0.217	0.196	0.268	0.217	0.293
	(0.85)	(0.79)	(1.14)	(1.00)	(1.36)
St. Andrew's	0.202	0.234	0.309	0.210	0.320
	(0.80)	(0.95)	(1.35)	(0.91)	(1.51)
St. Patrick's	1.073***	0.954***	1.006***	0.923***	1.023***
	(5.13)	(4.48)	(4.85)	(4.91)	(4.83)
St. David's	0.679**	0.608**	0.671**	0.583**	0.637**
	(3.02)	(2.69)	(3.21)	(2.88)	(2.95)
Grenadines	1.400***	1.324***	1.340***	1.216***	1.338***
	(5.28)	(5.14)	(5.71)	(5.36)	(5.30)
Agency	-0.241*	-0.225*	-0.201*	-0.247**	-0.278**
	(-2.41)	(-2.31)	(-2.22)	(-2.80)	(-3.05)
Ln Time	-0.085*	-0.082*	-0.066*	-0.063	-0.065*
	(-2.29)	(-2.51)	(-2.09)	(-1.79)	(-2.02)
Constant	0.117	0.208	0.170	0.242	0.217
	(0.51)	(0.96)	(0.82)	(1.30)	(0.99)
σ_u	0.479***	0.479***	0.456***	0.452***	0.460***
	(7.49)	(8.24)	(9.04)	(9.00)	(9.79)
σ_v	0.143***	0.134***	0.120***	0.130***	0.125***
	(5.85)	(6.06)	(5.63)	(4.23)	(5.08)
λ	3.359***	3.580***	3.790***	3.480***	3.688***
	(54.11)	(62.85)	(74.72)	(70.09)	(69.24)
χ^2	758	524	624	460	748

Table 5: Results of Battese Coelli (1995) models using hotdeck imputations. SEs adjusted for clustering by estate. t-statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

All models:
$N = 1666$ observations on 108 estates
Average length = 15.4 years

	Imputed data set				
	1	2	3	4	5
Frontier					
Ln Slaves	1.079***	1.066***	1.043***	1.089***	1.058***
	(21.13)	(23.75)	(23.22)	(23.60)	(22.49)
Ln Acres	-0.024	-0.016	0.009	-0.020	-0.001
	(-0.45)	(-0.33)	(0.19)	(-0.41)	(-0.01)
Ln Time	0.025	0.005	0.009	0.009	0.007
	(1.17)	(0.24)	(0.43)	(0.42)	(0.35)
Constant	0.041	0.072	0.076	-0.008	0.057
	(0.17)	(0.32)	(0.33)	(-0.04)	(0.26)
Mean inefficiency					
St. George's	0.369	0.357	0.320	0.345	0.294
	(1.59)	(1.41)	(1.55)	(1.52)	(1.42)
St. Andrew's	0.182	0.168	0.179	0.110	0.122
	(0.68)	(0.55)	(0.74)	(0.39)	(0.49)
St. Patrick's	1.027***	1.106***	0.973***	1.054***	0.964***
	(4.30)	(4.21)	(4.84)	(4.43)	(4.64)
St. David's	0.650**	0.687**	0.606**	0.647**	0.600**
	(2.89)	(2.71)	(3.14)	(2.86)	(2.97)
Grenadines	1.479***	1.515***	1.416***	1.522***	1.392***
	(5.14)	(4.91)	(5.98)	(5.17)	(5.46)
Agency	-0.258**	-0.264**	-0.336***	-0.291**	-0.214*
	(-2.84)	(-2.79)	(-3.95)	(-3.26)	(-2.56)
Ln Time	-0.069	-0.117*	-0.086	-0.118*	-0.102*
	(-1.35)	(-2.21)	(-1.71)	(-2.22)	(-1.96)
Constant	-0.003	-0.008	0.169	0.077	0.133
	(-0.01)	(-0.02)	(0.72)	(0.27)	(0.54)
σ_u	0.482***	0.499***	0.476***	0.503***	0.477***
	(9.79)	(9.89)	(11.06)	(10.12)	(10.13)
σ_v	0.186***	0.188***	0.167***	0.169***	0.169***
	(9.31)	(7.86)	(9.23)	(8.42)	(8.51)
λ	2.588***	2.649***	2.844***	2.974***	2.824***
	(52.29)	(49.24)	(64.34)	(63.12)	(61.12)
χ^2	901	1056	932	1104	1008

Table 6: Results of Battese Coelli (1995) models using chained equations imputations. SEs adjusted for clustering by estate. t-statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

All models:
$N = 1666$ observations on 108 estates
Average length = 15.4 years

	Imputed data set				
	1	2	3	4	5
Frontier					
Ln Slaves	0.487***	0.308***	0.397**	0.510***	0.415***
	(10.88)	(4.32)	(2.73)	(8.29)	(14.31)
Ln Acres	0.333***	0.147*	0.085*	0.097	0.099**
	(7.20)	(2.22)	(2.32)	(1.68)	(3.06)
Ln Time	-0.037***	-0.030***	-0.032***	-0.019**	-0.015
	(-5.69)	(-3.92)	(-4.17)	(-3.16)	(-1.73)
Constant	0.867***	2.678***	2.556***	1.711***	2.176***
	(6.48)	(5.78)	(3.97)	(4.15)	(15.20)
Mean inefficiency					
Agency	-0.847	-0.668	-0.669	-0.456	-0.479
	(-1.37)	(-1.30)	(-1.63)	(-1.37)	(-1.50)
Ln Time	-1.075*	-0.787*	-0.587***	-0.461**	-0.377**
	(-2.04)	(-2.17)	(-3.59)	(-2.66)	(-2.94)
σ_u	0.811***	0.673***	0.630***	0.564***	0.583***
	(3.78)	(4.04)	(5.82)	(5.03)	(7.30)
σ_v	0.075***	0.090***	0.094***	0.086***	0.053
	(5.32)	(6.77)	(2.82)	(5.47)	(1.30)
λ	10.82***	7.443***	6.718***	6.525***	11.004***
	(49.11)	(43.49)	(52.38)	(55.85)	(110.44)
χ^2	1089	55.16	45.94	93.49	427.68

Table 7: Results of Greene's true random effects models using hotdeck imputations. SEs adjusted for clustering by estate. t-statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

All models:
$N = 1666$ observations on 108 estates
Average length = 15.4 years

	Imputed data set				
	1	2	3	4	5
Frontier					
Ln Slaves	0.812***	0.850***	0.882***	0.957***	0.857***
	(10.57)	(11.51)	(11.70)	(13.22)	(15.49)
Ln Acres	0.018	0.036	0.043	-0.007	0.017
	(0.44)	(0.99)	(1.34)	(-0.17)	(0.51)
Ln Time	0.040*	0.032	0.030	0.039*	0.031*
	(2.27)	(1.91)	(1.83)	(2.23)	(1.98)
Constant	0.891*	0.576	0.361	0.267	0.651
	(2.21)	(1.55)	(0.97)	(0.56)	(1.91)
Mean inefficiency					
Agency	-0.439	-0.603*	-0.851**	-0.462*	-0.479*
	(-1.93)	(-2.13)	(-2.89)	(-2.19)	(-1.99)
Ln Time	-0.098	-0.167	-0.178	-0.156	-0.185
	(-0.94)	(-1.18)	(-1.31)	(-1.24)	(-1.47)
σ_u	0.491***	0.533***	0.576***	0.540***	0.546***
	(5.81)	(5.45)	(6.18)	(5.86)	(6.09)
σ_v	0.190***	0.197***	0.189***	0.184***	0.173***
	(14.46)	(11.42)	(11.15)	(11.98)	(11.11)
λ	2.587***	2.698***	3.053***	2.939***	3.159***
	(28.97)	(25.98)	(30.54)	(29.97)	(33.63)
χ^2	124	165	161	180	244

Table 8: Results of Greene's true random effects models using chained equations imputations. SEs adjusted for clustering by estate. t-statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

All models:
N = 1666 observations on 108 estates
Average length = 15.4 years

	Imputed data set				
	1	2	3	4	5
Frontier					
Ln Slaves	0.691***	0.724***	0.767***	0.873***	0.739***
	(8.96)	(8.28)	(8.77)	(11.18)	(10.96)
Ln Acres	0.015	0.031	0.045	-0.008	0.014
	(0.36)	(0.71)	(1.08)	(-0.18)	(0.34)
Ln Time	0.036*	0.030	0.027	0.037*	0.030*
	(2.10)	(1.81)	(1.64)	(2.15)	(1.98)
Mean inefficiency					
Agency	-0.414	-0.558*	-0.798**	-0.429*	-0.465*
	(-1.87)	(-2.05)	(-2.77)	(-2.02)	(-1.98)
Ln Time	-0.109	-0.157	-0.175	-0.152	-0.177
	(-1.08)	(-1.16)	(-1.37)	(-1.23)	(-1.51)
σ_u	0.474***	0.500***	0.543***	0.511***	0.526***
	(5.81)	(5.21)	(5.97)	(5.47)	(6.06)
σ_v	0.185***	0.194***	0.186***	0.182***	0.167***
	(14.22)	(10.93)	(10.49)	(11.08)	(10.49)
λ	2.562***	2.577***	2.913***	2.810***	3.157***
	(29.52)	(25.01)	(29.35)	(27.90)	(34.23)
χ^2	80	73	79	131	128

Table 9: Results of Greene's true fixed effects models using chained equations imputations. SEs adjusted for clustering by estate. t-statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

References

Aigner, D. J., Lovell, C. A. K., and Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, 6:21–37.

Andridge, R. R. and Little, R. J. A. (2010). A review of hot-deck imputation for survey non-response. *International Statistical Review*, 78(1):40–64.

Battese, G. E. and Coelli, T. J. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics*, 20:325–332.

Belotti, F., Daidone, S., Ilardi, G., and Atella, V. (2012). Stochastic frontier analysis using Stata. Centre for Economic and International Studies, University of Rome 'Tor Vegata', Italy.

Belotti, F. and Ilardi, G. (2012). Consistent estimation of the "true" fixed-effects stochastic frontier model. Centre for Economic and International Studies, University of Rome 'Tor Vegata', Italy.

Bloom, N. and Van Reenan, J. (2007). Measuring and explaining management practices across firms and countries. *Quarterly Journal of Economics*, CXXII(4):1351–1408.

Burhop, C. and Lübbers, T. (2009). Cartels, managerial incentives and productive efficiency in German coal mining, 1881-1913. *The Journal of Economic History*, 69(2):500–527.

Burnard, T. (2004). 'Passengers Only:' the extent and significance of absenteeism in eighteenth-century Jamaica. *Atlantic Studies*, 1:178–195.

Cameron, A. C. and Trivedi, P. K. (2005). *Microeconometrics. Methods and Applications.* Cambridge University Press, Cambridge, 8th edition.

Carlos, A. and Nicholas, S. (1990). Agency problems in early chartered companies: the case of the Hudson's Bay Company. *The Journal of Economic History*, 50:853–875.

Coelli, T., Rao, D. S. P., and Battese, G. E. (1998). *An introduction to efficiency and productivity analysis.* Kluwer, Mass., first edition.

Cole, A. H. (1938). *Wholesale Commodity Prices in the United States: 1700-1861.* Cambridge, Mass.

Cooke, B. (2003). The denial of slavery in management studies. *Journal of Management Studies*, 40:1895–1918.

Cowton, C. J. and O'Shaughnessy, A. J. (1991). Absentee control of sugar plantations in the British West Indies. *Accounting and Business Research*, 22:33–45.

Davidson, J. (1900). *Commercial Federation and Colonial Trade Policy.*

Field-Hendrey, E. (1995). Application of a stochastic production frontier to slave agriculture: an extension. *Applied Economics*, 27(4):363–368.

Fleishman, R. K. (2004). Confronting moral issues from accountancy's dark side. *Accounting History*, 9:7–23.

Forster, M. and Smith, S. D. (2011). Surviving slavery: mortality at Mesopotamia, a Jamaican sugar estate, 1762 - 1832. *Journal of the Royal Statistical Society, Series A*, 174:907–929.

Gayer, A. D., Rostow, W. W., and Schwartz, A. J. (1953). *The Growth and Fluctuation of the British Economy, 1790-1850 [microform]: an Historical, Statistical, and Theoretical study of Britain's Economic Development.* Microfilmed supplement to Volumes 1 and 2. Clarendon Press, Oxford.

Grabowski, R. and Pasurka, C. (1989). The relative efficiency of slave agriculture: an application of a stochastic production frontier. *Applied Economics*, 21(5):587–595.

Green, W. A. (1973). The planter class and British West Indian sugar production, before and after emancipation. *Economic History Review*, 26:449–454.

Greene, W. H. (2005). Fixed and random effects in stochastic frontier models. *Journal of Productivity Analysis*, 23:7–32.

Greene, W. H. (2011). *Econometric Analysis.* Prentice Hall, seventh edition.

Habib, M. A. and Ljungqvist, A. (2005). Firm value and managerial incentives: a stochastic frontier approach. *The Journal of Business*, 78(6):2053–2094.

Hall, D. (1964). Absentee proprietorship in the British West Indies, to about 1850. *Jamaican Historical Review*, 4:15–35.

Higman, B. W. (1976). *Slave Population and Economy in Jamaica, 1807-1834.* Cambridge University Press, Cambridge and New York.

Higman, B. W. (1984). *Slave Populations of the British Caribbean, 1807-1834.* Johns Hopkins University Press, Baltimore.

Higman, B. W. (1996). *Economic and social development in the British West Indies, from settlement to c. 1850.* In S. L. Engerman and R. E. Gallman (eds.), *The Cambridge Economic History of the United States. Volume 1, The Colonial Era.* Cambridge University Press, Cambridge.

Higman, B. W. (2005). *Plantation Jamaica: Capital and Control in a Colonial Economy.* University of the West Indies Press, Jamaica, Barbados and Trinidad and Tobago.

Hofler, R. A. and Folland, S. T. (1991). The relative efficiency of slave agriculture: a comment. *Applied Economics*, 23(5):861–868.

Kumbhakar, S. C., Lien, G., and Hardaker, J. B. (2012). Technical efficiency in competing panel data models: a study of Norwegian grain farming. *Journal of Productivity Analysis.*

Laws of St. Vincent (1884). Volume I(98). London.

Little, R. and Rubin, D. (2002). *Statistical analysis with missing data.* Wiley, New York.

London School of Hygiene and Tropical Medicine (2013). Missing data. `http://missingdata.org.uk`. Accessed 14th February, 2013.

Long, E. (1774). *The History of Jamaica, Volume 2.* First published 1774, London, 1974.

Mander, A. and Clayton, D. (1999). sg116: Hotdeck Imputation/1. Update to hotdeck imputation. *Stata Technical Bulletin STB-51*, pages 32–34. Reprinted in *Stata Technical Bulletin Reprints*, vol. 9, ed. H.J. Newton pages 196-199, 1999. College Station TX: Stata Corporation. Downloadable from `http://www.stata.com/products/stb/stb-table-of-contents/#9`.

Marshall, B. (2007). *Law and Society in the British Windward Islands, 1763-1823: A Comparative Study.* Arawak Publications, Kingston, Jamaica.

Meeusen, W. and van den Broeck, J. (1977). Efficiency estimation from Cobb-Douglas production functions with composed error. *International Economic Review*, 18:435–44.

Mitchell, B. R. (1988). *British Historical Statistics.* Cambridge University Press, Cambridge.

Olmstead, A. L. and Rhode, P. W. (2008). Biological innovation and productivity growth in the antebellum cotton economy. *The Journal of Economic History*, 68(4):1123–1171.

Pitman, F. W. (1927). The West Indian absentee planter as a British colonial type. In *Proceedings of the Pacific Coast Branch of the American Historical Association.*

Pitt, M. M. and Lee, L. (1981). The measurement and sources of technical inefficiency in the Indonesian weaving industry. *Journal of Development Economics*, 9:43–64.

Ragatz, L. J. (1927). *Statistics for the Study of British Caribbean Economic History, 1763-1833.* Bryan Edwards Press, London.

Ragatz, L. J. (1931). Absentee landlordism in the British Caribbean, 1750-1833. *Agricultural History*, V:7–24.

Rubin, D. and Schenker, N. (1986). Multiple imputation from random samples with ignorable non-response. *Journal of the American Statistical Association*, 81(394):366–374.

Rubin, D. B. (1987). *Multiple Imputation for Nonresponse in Surveys.* Wiley, New York.

Shephard, C. (1831). *An Historical Account of St. Vincent.* London.

Sheridan, R. B. (1971). Simon Taylor, sugar tycoon of Jamaica, 1740-1813. *Agricultural History*, 45:285–296.

Smith, S. D. (2006). *Slavery, Family and Gentry Capitalism in the British Atlantic: the World of Lascelles, 1648-1834.* Cambridge University Press, Cambridge.

Smith, S. D. (2008). An inspector calls: John Johnson's reports on slavery. *Slavery and Abolition*, 29:503–532.

Smith, S. D. (2010). Volcanic hazard in a slave society: the 1812 eruption of Mount Soufrière in St. Vincent. *Journal of Historical Geography*, 30:55–67.

Smith, S. D. (2013). *Slavery's Heritage Footprint: Linkages Between British Prestige Residencies and Plantations on St. Vincent, 1814-1824.* In Hahn, A. and Dresser, M. (eds.), *Slavery and the British Country House*, English Heritage, London.

Spinelli, J. (1973). *Land Use and Population in St. Vincent, 1763-1960: A Contribution to the Patterns of Economic and Demographic Change in a Small West Indian Island.* PhD thesis, University of Florida.

Stevenson, R. E. (1980). Likelihood functions for generalized stochastic frontier estimation. *Journal of Econometrics*, 13:57–66.

van Buuren, S., Boshuizen, H. C., and Knook, D. L. (1999). Multiple imputation of missing blood pressure covariates in survival analysis. *Statistics in Medicine*, 18:681–694.

van Passel, S., Lauwers, L., and van Huylenbroeck, G. (2006). *Factors of farm performance: an empirical analysis of structural and managerial characteristics.* In Mann, S. (ed.), *Causes and Impacts of Agricultural Structures*, Nova Science, New York.

Wang, H. J. (2002). Heteroskedasticity and non-monotonic efficiency effects of a stochastic frontier model. *Journal of Productivity Analysis*, 18:241–253.

Ward, J. R. (1988). *British West Indian Slavery, 1750-1834: the Process of Amelioration.* Clarendon Press, Oxford.

Watson, J. P., Spector, J., and Jones, T. A. (1958). *Soil and Land Use Surveys No. 3 St. Vincent.* Imperial College of Tropical Agriculture, Trinidad and Tobago.

Watts, D. (1987). *The West Indies: Patterns of Development, Culture and Environmental Change Since 1492.* Cambridge University Press, Cambridge.

Williams, E. (1944). *Capitalism and Slavery.* University of North Carolina Press, Chapel Hill, North Carolina.

Wooldridge, J. W. (2002). *Econometric Analysis of Cross Section and Panel Data.* The MIT Press, Cambridge, Mass.

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